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Laurel II (closed)
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NO-MIGRATION PETITION
FORMER LAUREL SANITARY LANDFILL
YELLOWSTONE COUNTY, MONTANA
LICENSE NO. 203

Huntingdon
Consulting Engineers Environmental Scientists

Chen-Northern, Inc., Division

[redacted]

NO-MIGRATION PETITION
FORMER LAUREL SANITARY LANDFILL
YELLOWSTONE COUNTY, MONTANA
LICENSE NO. 203

PETITION FOR NO-MIGRATION DEMONSTRATION
FORMER LAUREL SANITARY LANDFILL
YELLOWSTONE COUNTY, MONTANA
LICENSE NO. 203

Prepared for:

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May 1995

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1.0 INTRODUCTION

Personnel from Huntingdon Engineering and Environmental, Inc. (Huntingdon) prepared this no-migration petition for the portion of the City of Laurel's former sanitary landfill site which was permitted by the Montana Department of Health and Environmental Sciences under License No. 203. The purpose of preparing this petition is to demonstrate to the MDHES that there is no potential for hazardous constituents that may have been buried in the landfill to contaminate the uppermost aquifer at the site in accordance with the Administrative Rules of Montana Title 16, Chapter 14, Subchapter 7, Section 14 (ARM 16.14.714). According to ARM 16.14.714, MDHES may waive the requirement to monitor groundwater at the former Laurel Sanitary Landfill if this demonstration is acceptable to MDHES. If this no-migration petition is not acceptable, the City of Laurel will be required to monitor groundwater at the site for a period of 30 years from the time the landfill was closed.

1.1 SITE HISTORY

The City of Laurel historically operated a series of unlicensed and licensed solid waste landfills located in the northwest quarter of Section 33, Township 1 South, Range 24 East (Figure 1). According to information obtained from the MDHES by GeoResearch (1992), solid wastes were initially disposed at the site about 1965 in an unlicensed "dump" (Figure 2). During 1978, the City of Laurel reportedly opened the first licensed landfill at the site. The original licensed landfill area (License No. 24, Figure 2) consisted of approximately 10 acres and was used for solid waste disposal from approximately 1978 until about 1983 (GeoResearch, 1992). A second licensed area (License No. 203, Figure 2) was permitted in 1982 and was used until September, 1990. After September 1990, the City of Laurel began hauling wastes to the Billings Sanitary Landfill and closed the landfill. A transfer station was installed at the site in 1990

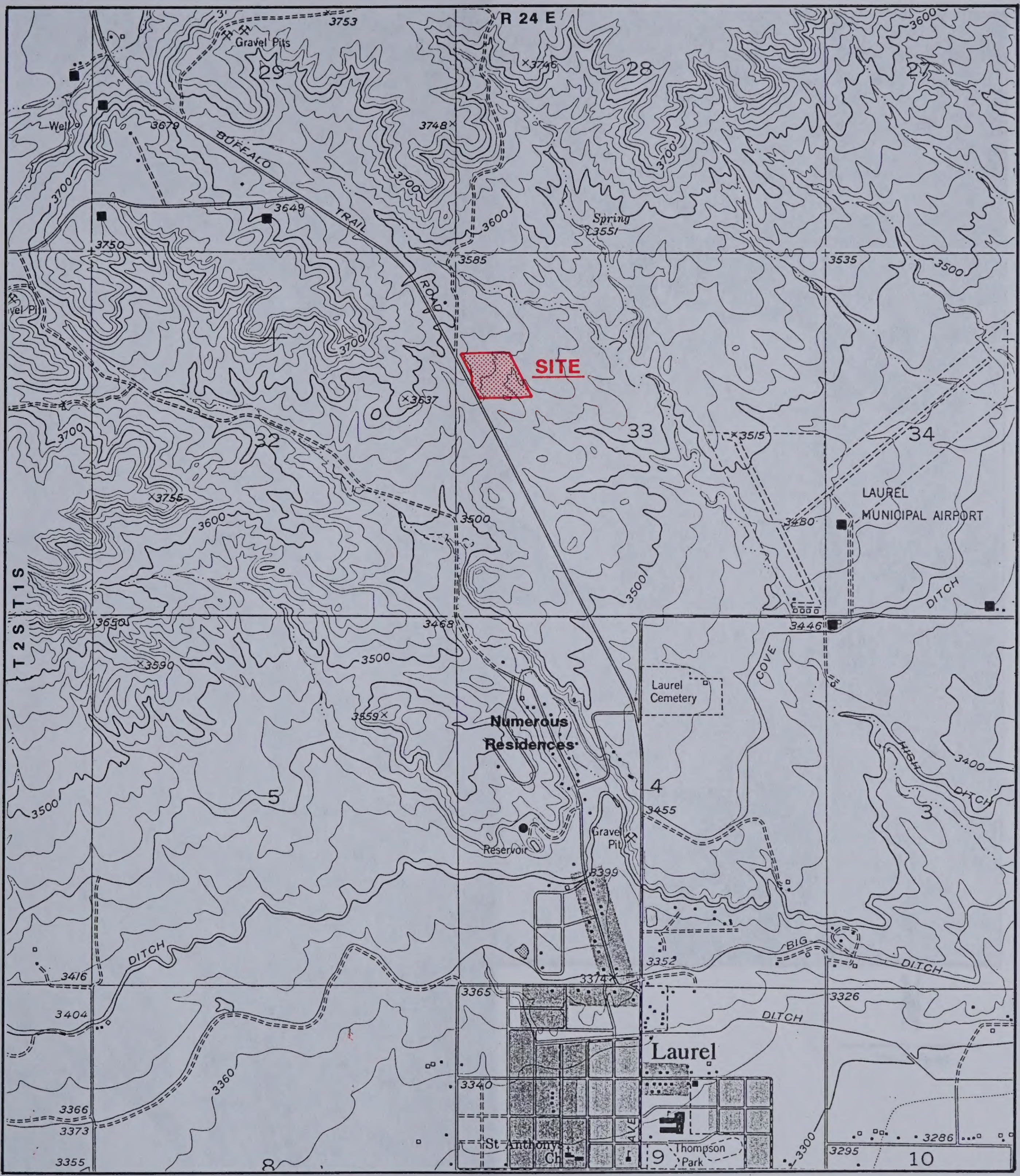
STATE LANDS

(?) Not true!

after 1/93

In accordance with Montana Code Annotated 75-10-207, owners and operators of municipal solid waste landfills that at any time accepted household waste, that were in operation as of October 1, 1989, and that serve a geographic area with a population of 5,000 or more persons, are required to monitor groundwater as specified by the MDHES. Wastes were not disposed in either the unlicensed landfill areas or the portion of the landfill that was permitted under License No. 24 after 1983. However, the portion of the former Laurel Sanitary Landfill permitted under License No. 203 served a population greater than 5,000 people and accepted wastes until September, 1990. Therefore, all

?
need inspection or
approved closure



From USGS 7.5' Laurel Quad

Yellowstone County, Montana

■ Residence

Location Map
Former Laurel Sanitary Landfill
North of Laurel, Montana
FIGURE 1

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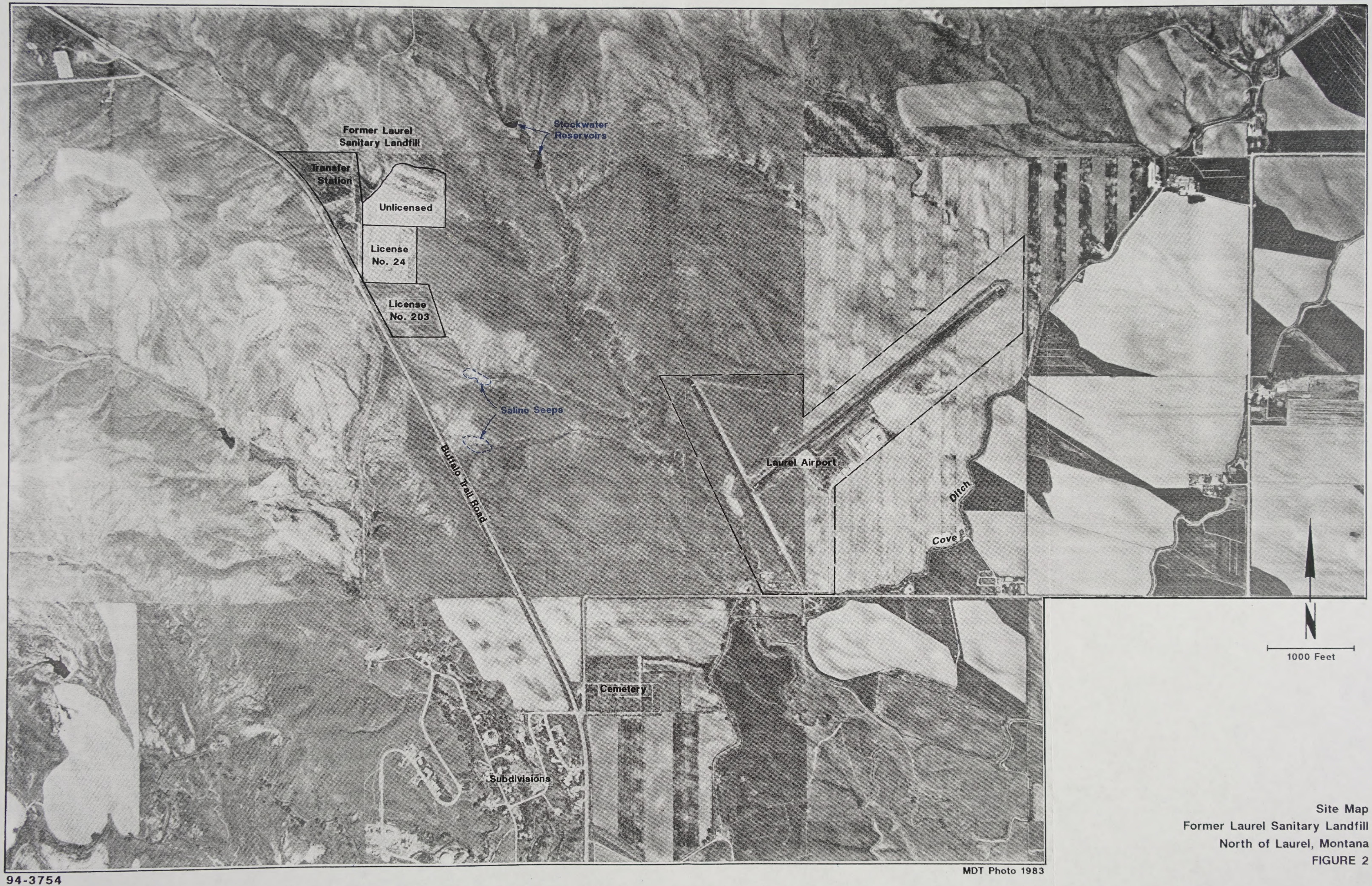


MDT Photo 1983

Site Map
Former Laurel Sanitary Landfill
North of Laurel, Montana
FIGURE 2

94-3754

groundwater monitoring requirements stipulated in ARM 16.14.7 apply to that area of the former landfill that operated under License No. 203.

According to ARM 16.14.714, groundwater monitoring at a landfill facility may be waived by the MDHES if the owner or operator can demonstrate that there is no potential for hazardous constituents to contaminate the uppermost aquifer. According to ARM 16.14.702(4), an "aquifer" is defined as any geological formation, group of formations or part of a formation capable of yielding significant quantities of groundwater to wells or springs. No-migration petitions must be based on site specific field collected measurements and contaminant fate and transport predictions that provide for conservative contaminant migration rates which provide for the greatest plausible impacts to human health and the environment. In addition, the no-migration petitions must demonstrate that groundwater in the uppermost aquifer will not become contaminated for at least 30 years after the facility is closed. It is our understanding that the MDHES has waived the groundwater monitoring requirement for at least four active municipal landfills in Montana, some of which exhibit hydrogeological characteristics similar to those at the former Laurel Sanitary Landfill.

Conditional
No migra.

1.2 OBJECTIVES

There are two general objectives of this no-migration petition:

- Establish that the upper water-bearing geological formations beneath the former Laurel Sanitary Landfill do not represent an "aquifer", as defined above, and;
- Demonstrate, using site-specific field data, that both the uppermost aquifer beneath the site and the nearest aquifer to the site will not become contaminated for at least 30 years from the time the landfill was closed.

According to ARM 16.14.714, if these objectives are met, the MDHES may waive groundwater monitoring requirements for the former Laurel Sanitary Landfill. If not, the City of Laurel will be required to monitor groundwater at the former landfill facility until the year 2020.

1.3 ENVIRONMENTAL SETTING

General descriptions of environmental characteristics of the area surrounding the former Laurel Landfill site are presented in this section. More detailed descriptions of the site are presented in a hydrogeology and soils study report previously prepared by GeoResearch (1992) and in later sections of this report.

1.3.1 Physiography/Demography

The former Laurel Sanitary Landfill is located in the northwest quarter of Section 33, Township 1 South, Range 24 East (Figure 1). The topography of the site and vicinity consists of gently rolling hills with numerous shallow swales that trend to the southeast (Figure 2). Photographs of the site are included in Appendix A. Based on our inspection of the site and on our review of topographic maps and air photos, it appears that the wastes disposed in the unlicensed landfill areas were placed in a southeast-trending ephemeral drainage located in the northwestern corner of Section 33. Waste disposed of in the two licensed landfill areas were placed in a shallower, less distinct southeast-trending swale (Figure 2).

trenches dug!

The unlicensed landfill area and that portion of the site permitted under License No. 24 appear to have been covered with varying thicknesses of soil and revegetated. Vegetation on the aforementioned landfill areas appears healthy (see photos in Appendix A). That portion of the site permitted under License No. 203 was capped with an 18-inch layer of low permeability soil, six-inches of top soil, and revegetated with native seed. Specific engineering components associated with the closure of this portion of the former landfill were approved by the MDHES in a letter to the City of Laurel dated November 19, 1992. Currently, vegetation on the portion of the landfill permitted under License No. 203 appears healthy (see photos in Appendix A).

Approval letter what does it include?

The nearest residences to the landfill include four homes located approximately one to one and one half miles northwest of the site, numerous homes in several subdivisions located approximately one mile south of the site, and two residences located near the Laurel Airport, approximately one mile southeast of the site. The City of Laurel is the nearest community to the former Laurel Sanitary Landfill.

1.3.2 Climate

The climate in the Laurel area is semi-arid with an average annual precipitation of approximately 14 inches (Gosling and Pashley, 1973). The mean annual evaporation rate in the Laurel area is about 45 inches, resulting in a net evaporation rate of approximately 31 inches (SCS, 1974). About 40 percent of the precipitation occurs from April to June in the form of rainstorms. The average annual temperature in the Laurel area is approximately 50° F (NOAA, 1993) with the highest temperatures occurring from June through August and the lowest temperatures occurring during January and February.

1.3.3 Geology

According to Gosling and Pashley (1973), surficial deposits at the former Laurel Sanitary Landfill consist of Quaternary-age slope wash deposits. Slope wash deposits at the site consist primarily of silt- and clay-size sediments with occasional gravel and cobble clasts derived from the Tertiary-age terrace deposits that cap several of the high benches north of the site. Unconsolidated slope wash deposits range in thickness from approximately 0 to 10 feet at the landfill site to as much as 100 feet near the Laurel Airport.

The slope wash deposits overlie shale bedrock of the Niobrara Formation (Balster, 1971) which is the upper-most formation of the Colorado Group. The Niobrara Formation consists of a dark gray to black marine shale that yields little to no water (Hall and Howard, 1929). Occasional thin beds of bentonite and sandstone are present throughout the Colorado Group; however, the sandy beds are generally dry or contain water of very poor quality (Hall and Howard, 1929).

The Colorado Group is approximately 2,000 feet thick in the Laurel area and is underlain by the Cloverly Formation. The Cloverly Formation corresponds to the Kootenai Formation to the north and west of Laurel. The Cloverly Formation consists of massive conglomeritic sandstone and is considered to be the upper-most geological formation in the area that is capable of yielding potable groundwater to wells (Gosling and Pashley, 1973).

So, what is dwlg
water source?
Surf wtr or
2,000' deep?

1.3.4 Hydrology

The Yellowstone River, located approximately four miles south of the landfill, is the nearest active surface water system to the landfill. Several man-made irrigation ditches are

located approximately one mile south of the landfill (Cove Ditch, High Ditch, Big Ditch, Figure 1). These ditches are only used to transmit water during the irrigation season.

There are several seeps noticeable within the north- south trending ephemeral drainage located approximately 1000 feet south-east of the landfill. Two earthen dams were constructed immediately downstream of one of the seeps to collect snowmelt, storm runoff, and seepage water for stock watering purposes (Figure 2). There was no evidence of overland surface flow above or below the reservoirs during an April, 1995 site visit. An additional seepage area is present approximately one quarter mile north of the earthen stock ponds. During April, 1995, this seepage area basically consisted of a "wet area" and surface flow was not evident below the seep (see photos in Appendix A). Two saline seep areas are present south of the former landfill (Figure 2), however; both areas were dry during an April, 1995 site visit.

1.3.5 Hydrogeology

Uppermost groundwater occurs beneath the landfill site at depths ranging from approximately six to 30 feet below ground surface. Groundwater encountered by monitoring wells at the site is hosted wholly within fractured shale of the Niobrara Formation. Based on observations made while installing and sampling monitoring wells at the landfill, the permeability of the Niobrara Shale is extremely low and yields very little water (GeoResearc, 1982). More detailed information regarding the permeability of the shale bedrock in presented in Section 3.0 of this report.

On a regional basis, the inability of the Niobrara Formation or other, lower units within the Colorado Group to yield water to wells is evident by the lack of domestic wells in the area. There are four homes within approximately one-mile northwest of the landfill (Figure 1). Residents of all four homes haul water and store water in cisterns. According to Mr. Jim Kukes (personal communication), a long-time resident of the area, a "dry well" was drilled to an unknown depth near the home located in the southwestern corner of Section 29, T1S, R24E (Figure 1).

Based on review of drillers' logs on file at the Montana Bureau of Mines and Geology in Billings, a stock well was apparently installed during 1950 in the southeast quarter of Section 32, T1S, R24E (Appendix A). The well reportedly penetrated 85 feet of black shale and was never used. The yield of this well is unknown.

The nearest wells to the landfill that are capable of producing "significant" quantities of water are located at the residences near the Laurel Airport and in the residential area located west of the cemetery (Figure 2). Review of available drillers' logs for these wells (Appendix B), indicates that groundwater tapped by the domestic wells is hosted within sand and gravel deposits that underlie the Quaternary-aged slope wash deposits and overly shale bedrock. A cross-section prepared by Gosling and Pashley (1973) shows that the sand and gravel aquifer penetrated by domestic wells south of the landfill extends north from the Yellowstone River to the approximate location of the Cove Ditch (Figure 3). Although these domestic wells appear to produce significant quantities of water, interviews with area residents indicate that these persons do not use the water for consumptive use because of the high mineral content of the water. Most homes in the area are equipped with cisterns that provide water for in-house use and businesses at the airport use bottled water for drinking purposes.

where are ditches
x-sec located on
map ?

In general, the quality of groundwater in the vicinity of the Laurel landfill is poor with relatively high concentrations of sulfate and sodium (Goshling and Pashley, 1973). The majority of residents outside service areas of the municipal water system for Laurel haul city water for domestic purposes. The municipal water supply for residents of Laurel is derived from the Yellowstone River.

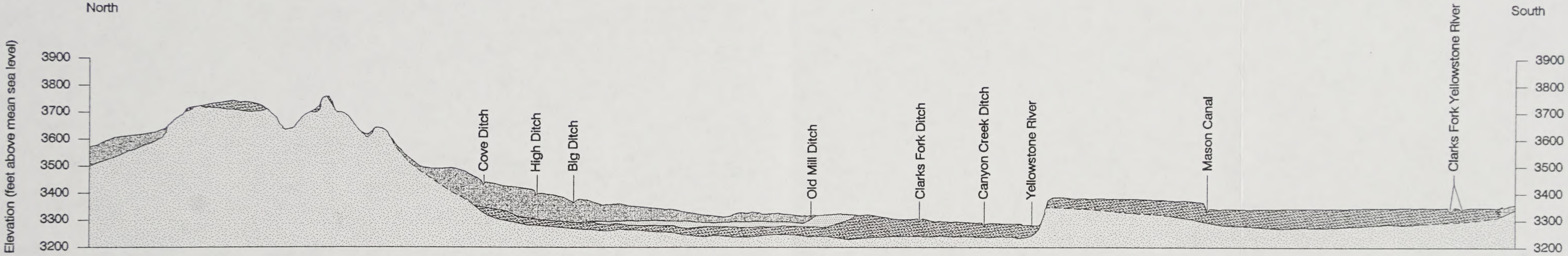
1.3.6 Land Use and Ownership

Land in the immediate vicinity of the former landfill is primarily used for cattle grazing. An area located on a high terrace bench approximately 1.5 miles north of the landfill is farmed using dryland methods. Few residences are located within one mile of the landfill, with the exception of those discussed in Section 2.1.

Land occupied by the former unlicensed and licensed areas is owned by the State of Montana. In addition, all land within Section 33, T1S, R24E is also owned by the State of Montana with the exception of the Laurel Airport, which is privately owned.

i.e. State LANDS

\94-3754\Litho.dwg



Lithologic Sections Showing Unconsolidated Deposits

0 1/2 1 Mile

Vertical Exaggeration X10

Gosling, Arthur W. and Pahsley, Jr., Emil F., 1973.

Loc on map?

▨	Bedrock	▨	Silt
▨	Gravel	▨	Sand

———- - - - - - Contact
(dashed where approximately located)

Huntingdon 94-3754

North-South Geologic Cross Section
Former Laurel Sanitary Landfill
North of Laurel, Montana
FIGURE 3

2.0 SITE CONDITIONS

In this section we present site-specific data collected at the former Laurel Sanitary Landfill. Interpretations of the data and conclusions with respect to the objectives of this no-migration demonstration are presented in Section 4.0.

2.1 GROUNDWATER OCCURRENCE AND MOVEMENT

GeoResearch installed five monitoring wells at the former Laurel Sanitary Landfill from. Monitoring wells MW-1, MW-2, MW-3, and MW-4 (Figure 4) are completed at total depths ranging from 20 to 55 feet below ground surface and intercept the upper-most water bearing geological formation at the site. Monitoring well MW-2D, located approximately 20 feet south of well MW-2, is completed at a total depth of 80 feet below ground surface and intercepts a deeper water-bearing unit than the other wells. Depth to water in well MW-2D is approximately 13 feet lower than the depth to water in well MW-2. The shallow water-bearing zone encountered by well MW-2 was apparently not noticeable while drilling the boring for well MW-2D (GeoResearch, 1994). This information, along with water quality data obtained from the wells (see Section 3.2) indicate that groundwater intercepted by well MW-2 is not directly connected with groundwater intercepted by well MW-2D. ✓

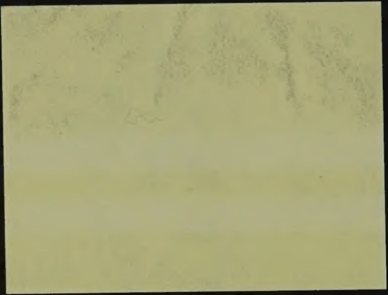
GeoResearch (1992) suggested that wells MW-2 and MW-4 are completed in unconfined water-bearing zones while wells MW-1 and MW-3 are completed in confined water-bearing zones. The basis for their interpretation was that wells MW-1 and MW-3 "displayed greater head" than wells MW-2 and MW-4. Based on our interpretation of information recorded on the lithologic and completion logs for the monitoring wells, all the wells intercept groundwater under unconfined conditions. The reason there is "greater head" in wells MW-1 and MW-3 is because these wells penetrate the water-bearing shale to a greater depth.

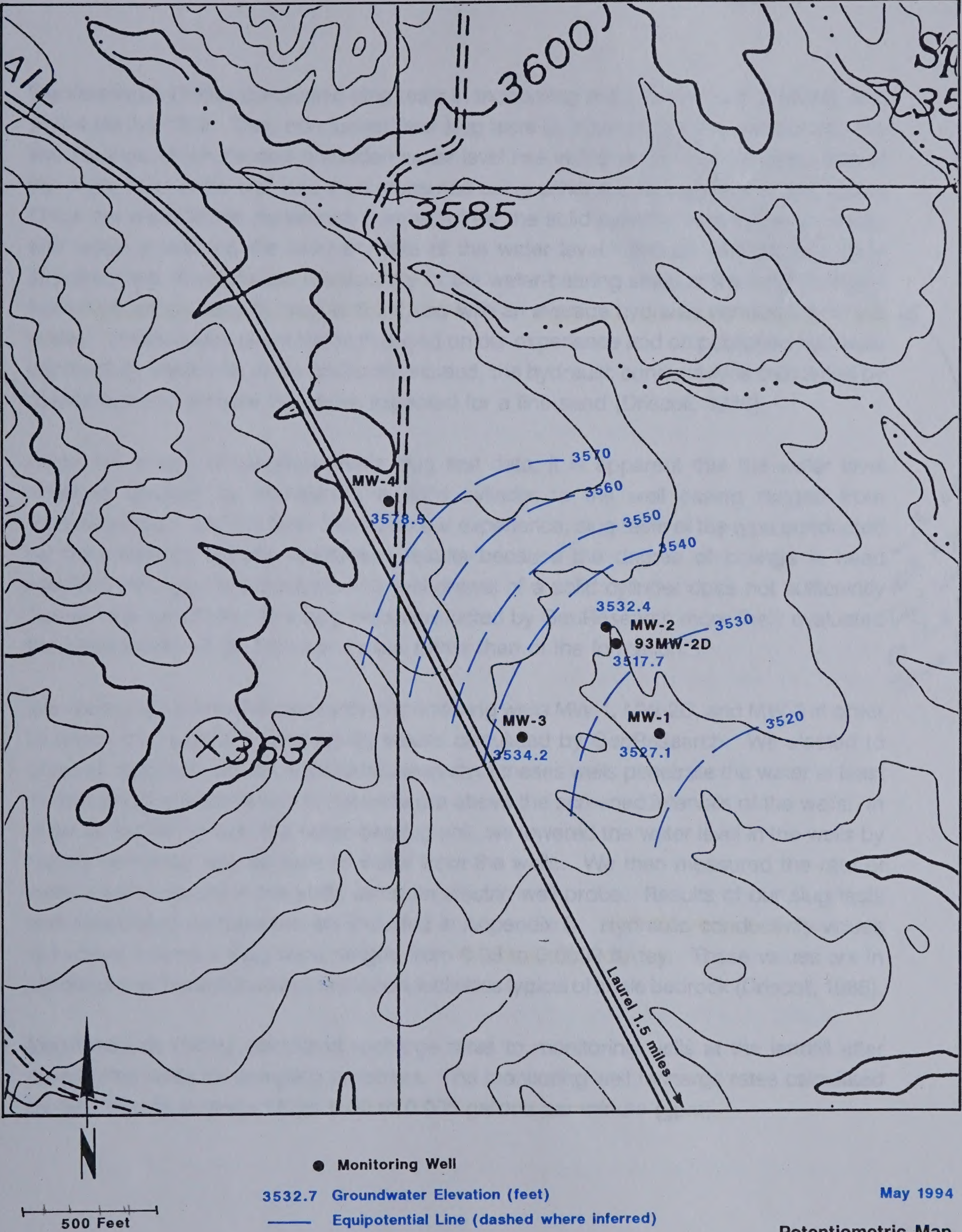
we Made this point too!

Based on water levels measured in monitoring wells MW-1, MW-2, MW-3, and MW-4, groundwater migrates beneath the former Laurel Sanitary Landfill to the southeast under gradients ranging from approximately 1% to 2.5% (Figure 4). Two saline seep areas are present in the ephemeral drainages south of the landfill (Figure 2). Saline seep is a discharge area for local salty groundwater (Custer, 1984).

mineralized

Of course, no
meandering indicated





May 1994

Potentiometric Map
Former Laurel Sanitary Landfill
North of Laurel, Montana
FIGURE 4

HE&E 94-3754

GeoResearch (1992) conducted slug tests in monitoring wells MW-1, MW-2, MW-3, and MW-4 during 1992. They conducted their slug tests by inserting a solid cylinder into the well casings which caused a sudden water level rise in the wells. The recovery rate of the water level in the well was then measured using either a data logger or a well probe. Once the water levels recovered, they withdrew the solid cylinder from the well casing, and again measured the recovery rate of the water level. Results of their slug tests indicated that the hydraulic conductivity of the water-bearing shale at the landfill ranged from 0.16 feet per day (ft/day) to 8.3 ft/day with an average hydraulic conductivity of 2.8 ft/day. These values seem too high based on our experience and on published hydraulic conductivity values for shale bedrock. Instead, the hydraulic conductivities calculated by GeoResearch are more like those expected for a fine sand (Driscoll, 1986).

From "our review" of GeoResearch's slug test data, it is apparent that the water level changes created by introducing a solid cylinder to the well casing ranged from approximately 1.2 to 1.8 feet. Based on our experience, slug tests of the type conducted by GeoResearch provide erroneous results because the degree of change in head resulting through the introduction or withdrawal of a solid cylinder does not sufficiently "stress" the formation. The slug tests conducted by GeoResearch more likely evaluated the permeability of the filter sand pack rather than of the formation.

this was only data Dept had! Dept commented on this several times!

We conducted additional slug tests in monitoring wells MW-1, MW-2D, and MW-3 in order to check the hydraulic conductivity values calculated by GeoResearch. We elected to conduct slug test in these wells because each of theses wells penetrate the water at least 10 feet and the water levels in the wells are above the screened intervals of the wells. In order to further "stress" the water-bearing unit, we lowered the water level in the wells by rapidly removing several bails of water from the wells. We then measured the rate of water level recovery in the wells using an electric well probe. Results of our slug tests and associated calculations are included in Appendix C. Hydraulic conductivity values calculated from our slug tests ranged from 0.08 to 0.0009 ft/day. These values are in agreement with published hydraulic conductivities typical of shale bedrock (Driscoll, 1986).

GeoResearch (1994) calculated recharge rates to monitoring wells at the landfill after purging the wells for sampling purposes. The monitoring well recharge rates calculated by GeoResearch ranged from 0.02 to 0.006 gallons per minute (gpm).

2.2 GROUNDWATER QUALITY

Sulfate, specific electrical conductance, and pH values measured in selected water samples collected from wells near the former Laurel Sanitary Landfill are plotted on Figure 5. Laboratory analytical results for water samples collected from domestic wells in the area are included in Appendix C. Sulfate concentrations in groundwater range from approximately 1000 milligrams per liter (mg/l) in wells located at the Laurel Airport and near the Cove Ditch to as high as 25,000 mg/l in monitoring well MW-1, located immediately downgradient of the former Laurel Sanitary Landfill. Although the State of Montana has not adopted a maximum contaminant level for sulfate, the secondary drinking water standard for sulfate is 250 mg/l. Sulfate concentrations in domestic wells located south of the former landfill are approximately four times higher than the secondary standard for sulfate, or higher.

Water quality data presented on Figure 5 indicate that three water-bearing units with distinctly different water quality types are present at and near the former Laurel Sanitary Landfill. The different water quality types are characterized as follows:

1) Groundwater with very high concentrations of sulfate, high specific conductance values, and relatively low pH (represented by landfill monitoring wells MW-1, MW-2, MW-3, and MW-4).

reducing no O_2 conditions

2) Groundwater with low concentrations of sulfate, high specific conductance values, and relatively high pH (represented by landfill monitoring well MW-2D).

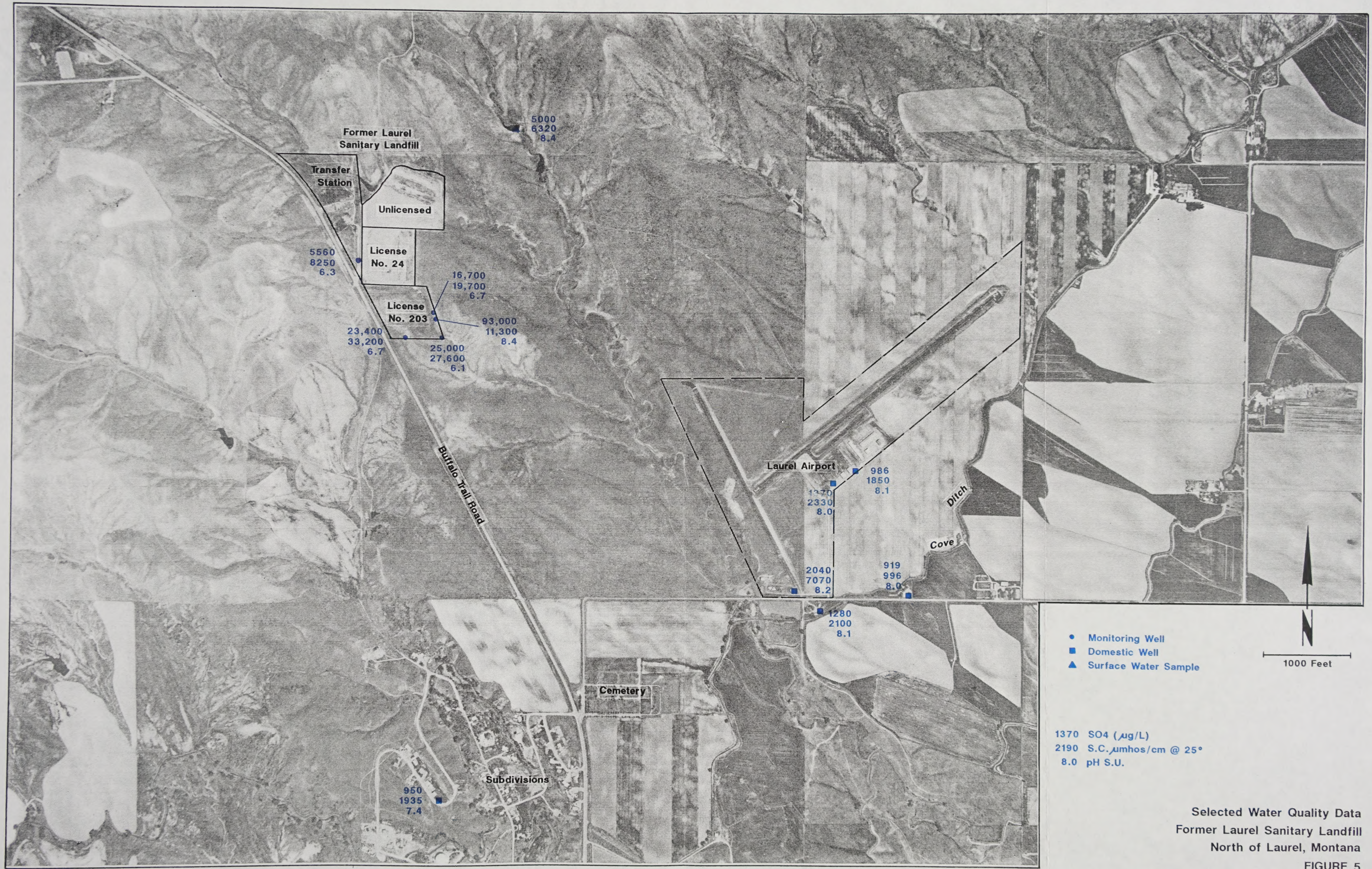
3) Groundwater with moderate concentrations of sulfate, moderate values of specific conductance, and relatively high pH values (represented by domestic wells located at the Laurel Airport and near the Cove Ditch).

similar because NOT impacted by ldfll.

According to ARM 16.20.1002, groundwater is classified using the following criteria:

Class I - Water having a specific electrical conductance of less than 1000 micromhos per centimeter (μmhos/cm) @ 25° C.

Class II - Water having a specific electrical conductance ranging from 1000 to 2500 μmhos/cm @ 25° C.



94-3754

MDT Photo 1983

Selected Water Quality Data
Former Laurel Sanitary Landfill
North of Laurel, Montana
FIGURE 5

Class III - Water having a specific electrical conductance ranging from 2500 to 15,000 μmhos/cm @ 25° C.

Class IV - Water having a specific electrical conductance greater than 15,000 μmhos/cm @ 25° C.

Groundwater intercepted by domestic wells located at the Laurel Airport and other domestic wells located north of the Cove Ditch is considered to be either Class II or III water. Class II water is considered to be marginally suitable for public and private water supplies. Class III water is suitable for some industrial and commercial uses, as drinking water for some wildlife and livestock, and for irrigation of some salt-tolerant crops. As discussed in Section 2.5, none of the persons served by the domestic wells shown on Figure 1 use the wells for drinking water. Groundwater intercepted by monitoring wells at the landfill are considered to be either Class III or IV water. Class IV water may be suitable for some industrial, commercial, and other uses, but is unsuitable for higher class beneficial use. According to information recorded by Gosling and Pashley (1973) virtually all groundwater they sampled from locations north of the Yellowstone River in the Laurel area is considered Class II or Class III groundwater.

$\frac{ft}{yr}$

$\frac{2.3\ ft}{1\ yr} \times 30\ yrs = 69\ ft$

69' ÷ 2.3 = 30 yrs

7' ÷ 2.3 = 3.0

3.0 CONTAMINANT TRANSPORT

In this section we present site-specific data collected at the former Laurel Sanitary Landfill that we used to evaluate the rate of contaminant transport at the landfill. Conclusions with regard to the objectives of this document are presented in the following section.

The rate of vertical and horizontal contaminant migration in water-bearing formations at the Laurel Sanitary Landfill can be calculated using the following equation:

$$v_x = \frac{Ki}{n_e}$$

where: v = average linear velocity in the *x* direction

K = hydraulic conductivity

i = hydraulic gradient

n_e = effective porosity of fractured medium

Hydraulic conductivity values, hydraulic gradients, and effective porosities for shale bedrock at the former Laurel Sanitary Landfill are summarized in Table 1 along with resultant migration rates calculated using the above equation. Based on calculations summarized in Table 1, if any contaminants released from the former Laurel Sanitary Landfill are able to infiltrate to the underlying water-bearing formation, the contaminants will migrate vertically at rates ranging from approximately 0.2 to 2.3 feet per year. Therefore, the maximum depth at which the contaminants could migrate after 30 years would be approximately 69 feet. Horizontal groundwater migration rates calculated for the former Laurel Sanitary Landfill range from 0.03 to 6.2 feet per year. Therefore, the maximum distance contaminants are expected to migrate laterally from the landfill over the course of 30 years is approximately 186 feet.

TABLE 1
SUMMARY OF VERTICAL AND HORIZONTAL MIGRATION RATES
FORMER LAUREL SANITARY LANDFILL

Vertical Migration Rates				
K (ft/day)	***i***	**n_e**	**Rate (ft/day)**	**Rate (ft/yr)**
8×10^{-8} cm/sec = (1)2.3 x 10^{-4}	(3)28%	(5)10%	6.4 x 10^{-4}	0.2
(1)2.3 x 10^{-4}	(3)28%	(5)1%	6.4 x 10^{-3}	2.3
Horizontal Migration Rates				
MW2D (2)9 x 10^{-4} .0009	(4)1%	(5)10%	9 x 10^{-5}	0.03
MW1 & MW3 (2)7 x 10^{-2} .08	(4)2.5%	(5)1%	1.7 x 10^{-2}	6.2

7' ÷ .2 = 35 yrs.

7' ÷ 2.3 = 3 yr.

50' ÷ .03 = 1667 yr

50 ÷ 6.2 = 8.06 yr

(1) Calculated from single ring infiltrometer test (GeoResearch, 1992).
(2) Calculated from slug tests conducted in wells MW-1, MW-2D, and MW-3.
(3) Vertical hydraulic gradient measured at paired wells MW-2 and MW-2D.
(4) Calculated from water levels measured in on-site monitoring wells.
(5) Range of effective porosity values for shale (Prickett, 1994).

MW-1 = .08
MW2D = .00089
MW-3 = .011

I used GeoRe. slug-in test data for K.

4.0 CONCLUSIONS

As discussed in Section 1.1, an "aquifer" is defined in ARM 16.14.702(4) as any geological formation, group of formations or part of a formation capable of yielding significant quantities of groundwater to wells or springs. Recharge rates to monitoring wells completed in shale bedrock at the former Laurel Sanitary Landfill range from 0.02 to 0.006 gpm. In our opinion, yields of this magnitude are not considered to be "significant." In addition, hydraulic conductivity values calculated from slug tests conducted in monitoring wells at the landfill range from 0.07 to 0.0009 ft/day which are typical values for shale bedrock. We judge stratigraphic units which have hydraulic conductivity values of this range in magnitude as not being significant aquifers.

all wells or just MW 2D

1993 -- originally MW-2D recharge rate 1.1×10^{-4} gpm, or 0.16 gpda.

The inability of shale bedrock formations of the Colorado Group to serve as an aquifer is further supported by the fact that none of the homes located immediately northwest of the site have wells. In addition, based on available water quality data, groundwater hosted within shale bedrock at the site is considered to be either Class III or IV water. According to ARM 16.20.1002, neither Class III or IV groundwater is suitable for human consumption.

possible impacted WQ conditions due to ldfill

Jon's letter

In their letter to the City of Laurel dated February 23, 1995, the MDHES agreed that the water-bearing zone intercepted by monitoring wells at the former Laurel Landfill is not the uppermost aquifer at the site. However, in their letter, MDHES implied that the uppermost water-bearing geological formation at the landfill could be a part of a group of formations that could constitute an aquifer.

As discussed in Section 1.1.3, the Niobrara Formation is the uppermost formation of the Colorado Group. The Colorado Group is approximately 2,000 feet thick in the Laurel area and is entirely composed of shale. Throughout eastern Montana, the Colorado Group is generally recognized as a geological formation that yields little to no water to wells and that water within the Colorado Group is highly mineralized and unpotable (Hall and Howard, 1929). The Big Horn County landfill, located near Hardin, Montana, is also situated on the Niobrara Formation. The Big Horn County landfill has received a no-migration variance from MDHES. Therefore, the MDHES has previously determined that the Colorado Group is not an aquifer.

The Cloverly Formation is the uppermost "aquifer" beneath the former Laurel Sanitary Landfill. In the Laurel area, the Cloverly Formation occurs at a depth of approximately

2000 feet. Based on data collected at the former Laurel Sanitary Landfill, the vertical migration rate of groundwater beneath the site ranges from approximately 0.2 to 2.3 feet per year. Therefore, the maximum depth at which the contaminants could migrate after 30 years would be approximately 70 feet.

The nearest "aquifer" to the former Laurel Sanitary Landfill consists of sand and gravel lenses penetrated by domestic wells located at and near the Laurel Airport and at the subdivided area southwest of the site. However, even though the wells appear to yield "significant" quantities of water, the water is considered by residents in the area to be unpotable because of the high mineral content of the water. This fact in itself supports our contention that the former Laurel Sanitary Landfill does not pose a risk to human health and the environment via the exposure of landfill-related contaminants in groundwater. The nearest wells to the former landfill that penetrate an "aquifer" are located at distances of approximately 4,000 feet or more from the site. Based on data collected at the site, groundwater migrates through the shale bedrock at rates ranging from approximately 0.3 to 6.2 feet per year. Therefore, the maximum distance to which contaminated groundwater could migrate laterally from the landfill within the regulatory time-frame of 30 years is on the order of 190 feet.

Solid wastes have not been disposed of in the former Laurel Sanitary Landfill since September, 1990. The landfill has been covered with 18 inches of low permeability material, six inches of topsoil, and revegetated. These actions, combined with the fact that the former landfill is located in a net evaporation zone, will further limit the opportunity for any contaminants to impact human health and/or the environment.

??

5.0 LIMITATIONS

The findings and opinions conveyed in this report are based upon information obtained at and near the former Laurel Sanitary Landfill and from a variety of other sources enumerated herein which we believe are reliable. The work was performed in accordance with the generally accepted practices of other consultants undertaking similar studies at this time and in the same geographical area. In completing this project, Huntingdon observed the degree of care and skill generally exercised by other consultants operating under similar circumstances and conditions. Huntingdon's findings and conclusions must be considered not as scientific certainties, but as opinions based on our professional judgement concerning the significance of the data gathered during the course of the evaluation. Other than this, no warranty is expressed or implied.

Prepared by:
Patrick Dunlavy
Senior Hydrogeologist

Reviewed by:
Myles F. Grotbo
Regional Technical Advisor

6.0 REFERENCES

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APPENDIX A

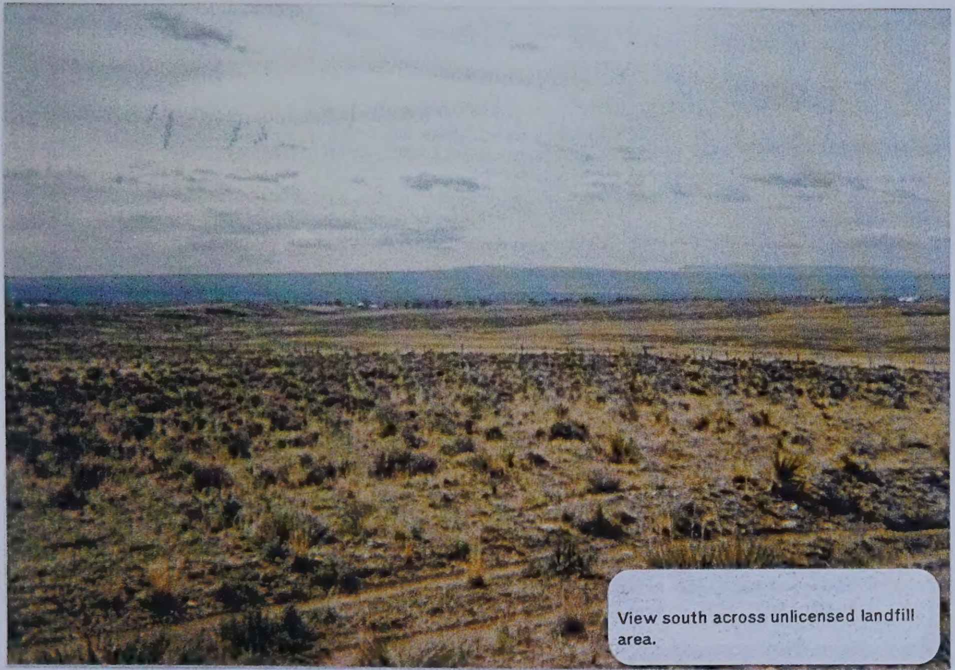
PHOTOGRAPHS
FORMER LAUREL SANITARY LANDFILL AND VICINITY

View south from bench north of landfill.

Stock watering reservoir northeast of landfill. View south.

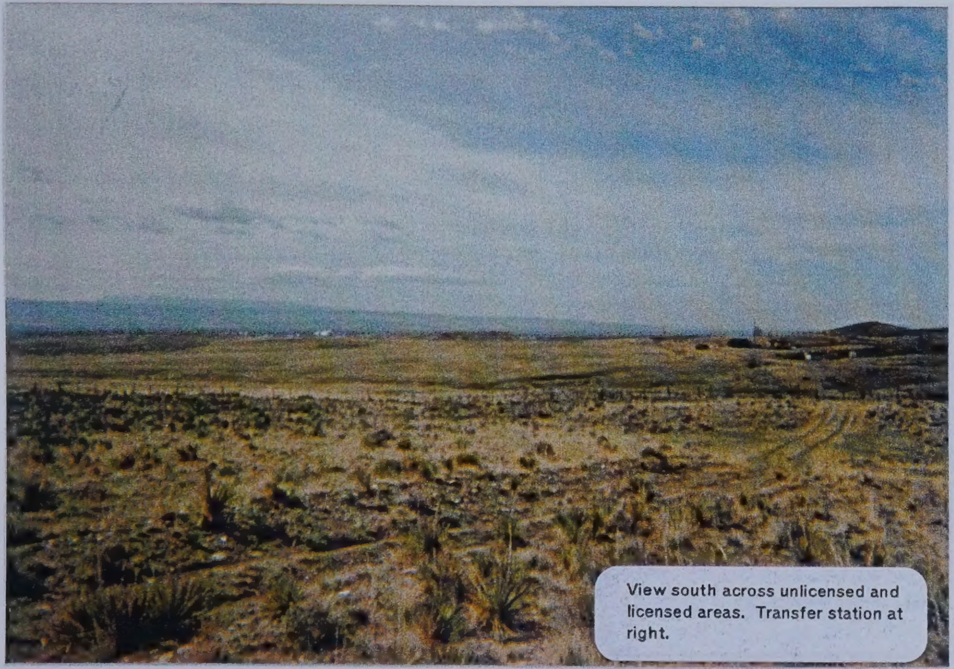
Northernmost seepage area.

Drainage immediately below northernmost seepage area. View south.



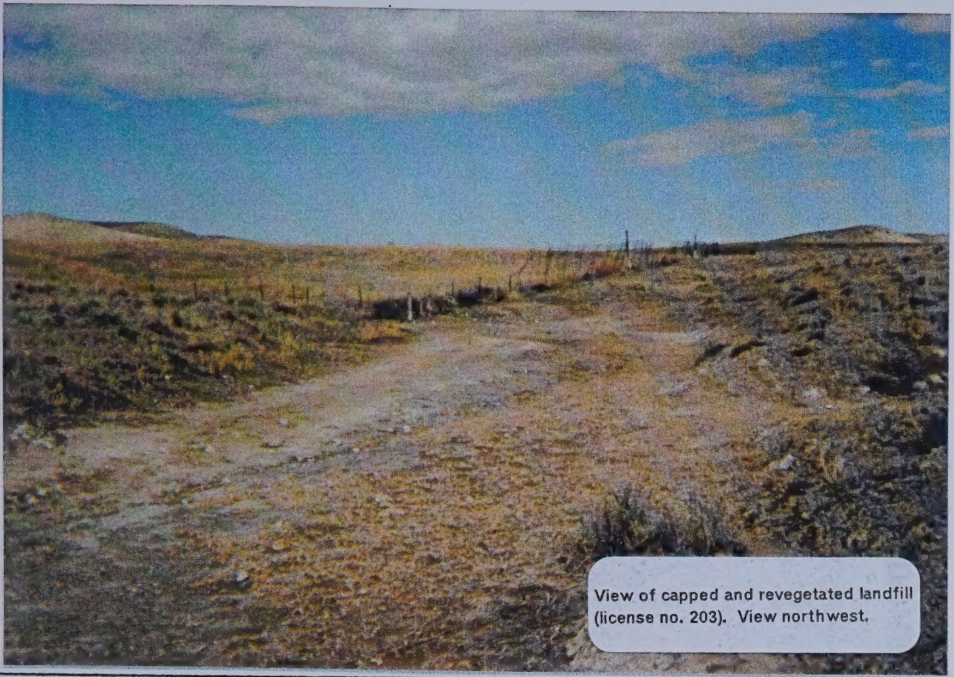
View south across unlicensed landfill area.

View South. Landfill license no. 203.

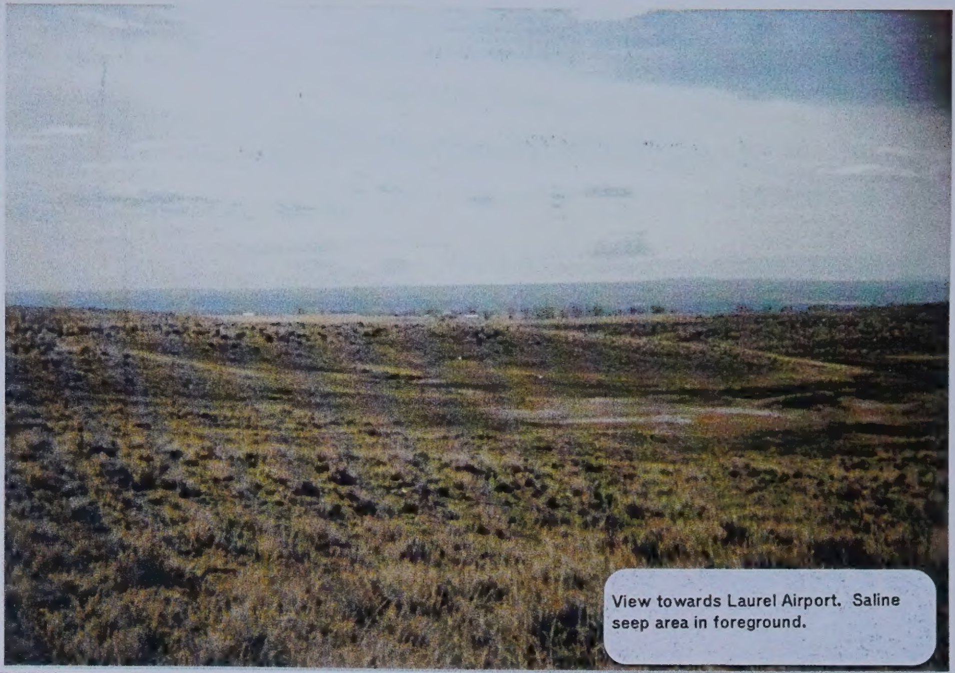


View south across unlicensed and licensed areas. Transfer station at right.

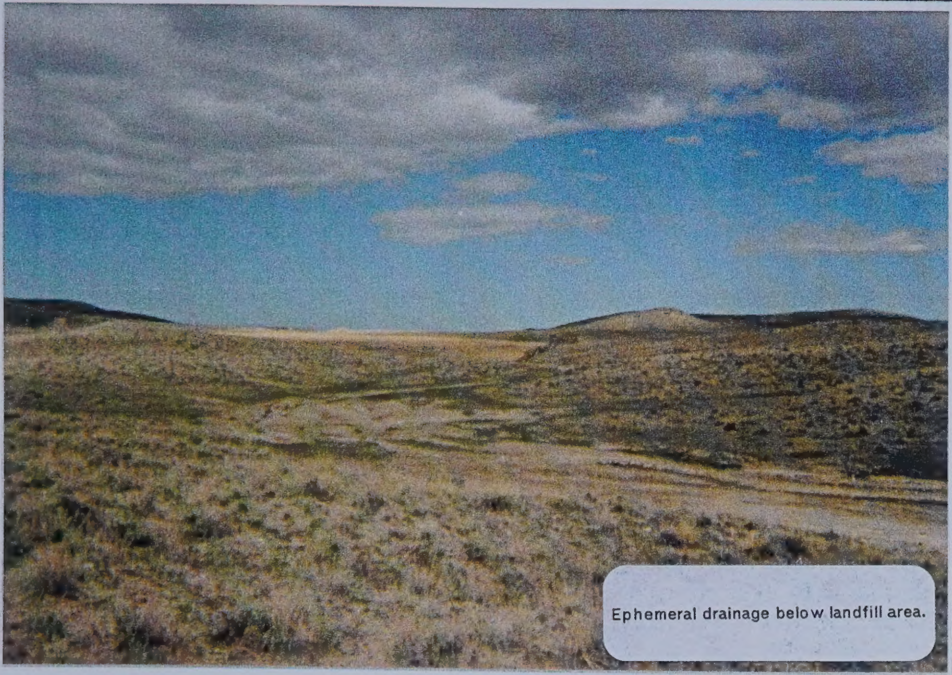
Monitoring well MW-2D. Revegetated area. View south.



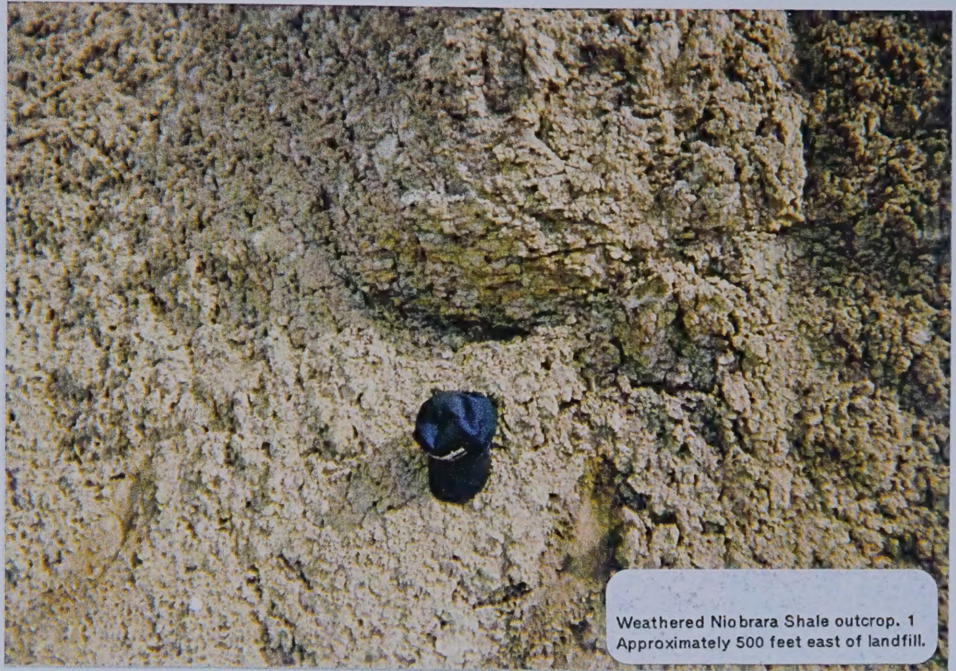
View of capped and revegetated landfill (license no. 203). View northwest.



View towards Laurel Airport. Saline seep area in foreground.



Ephemeral drainage below landfill area.



Weathered Niobrara Shale outcrop. 1 Approximately 500 feet east of landfill.

APPENDIX B

DRILLERS' LOGS FOR SELECTED DOMESTIC WELLS

111 1S 24E 34 CB

Yellowstone

Form No. 603 (R 6-84)

File No.__________

- No drinking OF wate.
Top Hand

WELL LOG REPORT

Sandy

State law requires that this form be filed by the water well driller within 60 days after compl No. 015734

1. WELL OWNER Nov Top Hand Air sprayers
Name MIKE VISSER 628-2409

2. CURRENT MAILING ADDRESS
MR MIKE VISSER
RAPELJE, MT 59067

3. WELL LOCATION
County YELLOWSTONE
Township 1 N/[✓ S] Range 24 [✓ E]/W
___ 1/4 ~~SW~~ ~~SE~~ 1/4 Section ~~33~~ 34
Lot NW SW Block
Subdivision ADJACENT TO VISSER HANGER

4. PROPOSED USE Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify CROP DUSTING SUPPLY

5. DRILLING METHOD ___ cable, ___ bored,
X forward rotary, ___ reverse rotary, ___ jetted,
___ other (specify)

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations 1/8 INCH and/or Screen — Kind Size	From (feet)	To (feet)
8 3/4"	6 5/8" 1/4 WALL STEEL	0'	15'	1/8" 12 PER FOOT	76'	110'
8 3/4"	6 5/8" 160 PSI PVC	15'	110'			

Was casing left open end? ___ Yes X No
Was a packer or seal used? X Yes ___ No
If so, what material CEMENT @ 15'
Was the well gravel packed? X Yes ___ No
Was the well grouted? X Yes ___ No
To what depth? 15'
Material used in grouting BENTONITE SLURRY
Well head completion: Pitless adapter X Yes ___ No
Top of casing 12 in. or greater above grade X Yes ___ No

7. WHAT IS THE TEMPERATURE OF THE WATER?
45 Degrees Fahrenheit
☐ Measured ☒ Estimated

8. WATER LEVEL
Static water level 70' feet below land surface
If flowing; closed-in pressure ___ psi
___ gpm
Controlled by: ___ valve, ___ reducers,
___ other, (specify)

9. WELL TEST DATA ___ pump ___ bailer
___ other, (specify) AIR PUMP
Pumping water level below land surface:
80 ft. after 2 hrs. pumping 35 gpm
80 ft. after 4 hrs. pumping 35 gpm

10. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If yes, how?

11. DATE COMPLETED

12. WELL LOG

Depth (ft.) From	To	Formation
0'	30'	SOIL, SHALE, GRAVEL
30'	70'	SHALE, CLAY
70'	110'	SAND GRAVEL, CLAY

RECEIVED
MAR 18 1986
DEPT. OF NATURAL RESOURCES AND CONSERVATION
BILLINGS OFFICE

HD

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Date 3/18/86
Firm Name SWEETWATER DRLG. & EXPLORATION INC.
Address P.O. BOX 123 BILLINGS, MT
Signature Ted H. Williams License No. 468

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59620 444-6610

State Publishing Co., Helena, Mont.

DEPARTMENT - BUREAU COPY

M: 927

Billings 111

1S 24E 34 CDD

Yellowstone

Form No. 603 (R 6-87)

File No. ______

WELL LOG REPORT

022263

State law requires that this form be filed by the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name Harvey E AND Melody E Fox

2. CURRENT MAILING ADDRESS
8325 Airport Rd.
Laurel, Mt. 59044

3. WELL LOCATION
County Yellowstone
Township 1 [✓ S] Range 24 [✓ E] W
SE ¼ SE-SW ¼ Section 34
Lot ______ Block ______
Subdivision ______
Tract Number ______

4. PROPOSED USE Domestic ☐ Stock ☑ Irrigation ☐
Other ☐ specify ______

5. DRILLING METHOD ✓ cable, ______ air rotary, ______ forward rotary, ______ reverse rotary, ______ jetted, ______ other (specify) ______

Depth (ft.) From	To	Formation
0	5	Gravel & SAND
5	45	SAND with som Brn clays
45	67	Clay With sand Stringers
67	74	SAND Med fine (Water Bearing)
74	82	Sand & Gravel

ATTACH ADDITIONAL SHEETS IF NECESSARY

7. WELL CONSTRUCTION AND COMPLETION

Perforations ~~None~~ and/or Screen None

Size of drilled hole	Size and PSI Rating of casing	From (feet)	To (feet)	Kind Size	From (feet)	To (feet)
6"	6"	12	82	10 ft	factory	slotted
	inserted liner			casing from		
	4½" PVC	20	82		72 ft	82 ft

Was casing left open end? ✓ Yes ______ No
Was a packer or seal used? ______ Yes ✓ No
If so, what material ______
Was the well gravel packed? ______ Yes ✓ No
To what depth was the well grouted? 82 ft
Material used in grouting Bentonite
Pitless adapter ______ Yes ______ No
Top casing 18 in. or greater above grade ✓ Yes ______ No

8. WELL TEST DATA

The pump test information request in this section is required for all wells. All depth measurements shall be from the top of the well casing unless otherwise specified.

All wells under 100 gpm must be tested for a minimum of one hour and provide the following information:

a) Air ______ Pump ✓ Bailer ______
b) Static water level immediately before testing 40 ft. If flowing; closed-in pressure ______ psi ______ gpm
Controlled by: ______ valve, ______ reducers, ______ other, (specify) ______
c) Depth at which pump is set for test 78
d) The pumping rate and means of discharge (i.e., bailing, airlift, pumping) 50 gpm
e) Maximum drawdown during the test 50 ft
f) Duration of test: Pumping time 3 hrs
Recovery time 2 hrs
g) Recovery water level 40 ft
Amount of time after pumping recovery level water data was taken 12 hrs

Wells intended to yield 100 gpm or more shall be tested for a period of 8 hours or more. The test shall follow the development of the well, and shall be conducted continuously at a constant discharge at least as great as the intended appropriation. In addition to the above information, water level data shall be collected and recorded on the Department's "Aquifer Test Data" form included in each packet of well logs.

NOTE: All wells shall be equipped with an access port ½ inch minimum or a pressure gauge that will indicate the shut-in pressure of a flowing well. Removable caps are acceptable as access ports.

9. WAS WELL PLUGGED OR ABANDONED? ______ Yes ✓ No
If yes, how? ______

10. DATE COMPLETED 11-12-87

11. DRILLER/CONTRACTOR'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

11-18-87
Date

KAK Well Service
Firm Name

209 6th Ave. Laurel, MT. 59044
Address

Signature 435
License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION

1520 EAST SIXTH AVENUE HELENA, MONTANA 59620-2301 444-6610

DNRC

DEPARTMENT — BUREAU COPY

111 01S 24E 32DD Yellowstone

GW 4

Approved Stock Form—State Publishing Co., Helena, Montana—42234

File No.

T. 1S R. 24E 32

County [illegible]

TRIPLICATE

RECEIVED
DEC 31 1963
Montana Bureau of Mines and Geology

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

019225

(4)

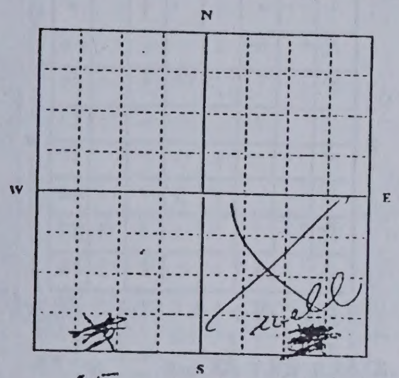
Declaration of Vested Groundwater Rights

(Under Chapter 237, Montana Session Laws, 1961)

1. [illegible], of Rt 1 [illegible]
(Name of Appropriator) (Address) (Town)

County of [illegible] State of Mont.

have appropriated groundwater according to the Montana laws in effect prior to January 1, 1962, as follows:



~~[illegible]~~ SE ¼ ~~[illegible]~~ SE Sec. 32 T. 1S R. 24E

Indicate point of appropriation and place of use, if possible. Each small square represents 10 acres.

2. The beneficial use on which the claim is based [illegible]

3. Date or approximate date of earliest beneficial use; and how continuous the use has been 1950

4. The amount of groundwater claimed (in miner's inches or gallons per minute) 20 [illegible]

5. If used for irrigation, give the acreage and description of the lands to which water has been applied and name of the owner thereof not used

6. The means of withdrawing such water from the ground and the location of each well or other means of withdrawal. [illegible]

7. The date of commencement and completion of the construction of the well, wells, or other works for withdrawal of groundwater 1950

8. The depth of water table [illegible]

9. So far as it may be available, the type, size and depth of each well or the general specifications of any other works for the withdrawal of groundwater [illegible]

10. The estimated amount of groundwater withdrawn each year [illegible]

11. The log of formations encountered in the drilling of each well if available [illegible]

12. Such other information of a similar nature as may be useful in carrying out the policy of this act, including reference to book and page of any county record

Signature of Owner [illegible]

Date [illegible] 1963

Three copies to be filed by the owner with the County Clerk and Recorder of the county in which the well is located.

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

Original to the County Clerk and Recorder; Duplicate to the State Engineer; Triplicate to the Montana Bureau of Mines and Geology, and Quadruplicate for the Appropriator.

GW 4

File No. 111 02S 24E 03 BBB

TRIPLICATE Yellowstone

T. 2 S. R. 24 E.

County Yellowstone

019737

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

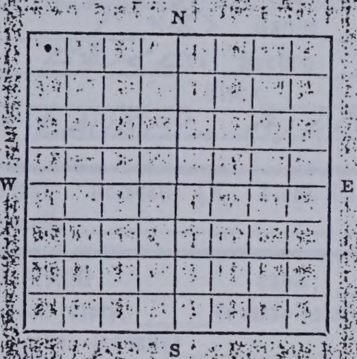
Declaration of Vested Groundwater Rights

(Under Chapter 237, Montana Session Laws, 1961)

1. Henry Foos (Name of Appropriator) of Box ~~XXX~~ 252 Rte. #1 (Address) Laurel (Town)

County of Yellowstone State of Montana

have appropriated groundwater according to the Montana laws in effect prior to January 1, 1962, as follows:



NW ¼ Sec. ~~2X~~ 3 T.2S R.24 E.

Indicate point of appropriation and place of use, if possible. Each small square represents 10 acres.

2. The beneficial use on which the claim is based Home and cattle

3. Date or approximate date of earliest beneficial use; and how continuous the use has been 1941 continuous

4. The amount of groundwater claimed (in miner's inches or gallons per minute) 10 gallons per minute

5. If used for irrigation, give the acreage and description of the lands to which water has been applied and name of the owner thereof none

6. The means of withdrawing such water from the ground and the location of each well or other means of withdrawal pump electric motor

7. The date of commencement and completion of the construction of the well, wells, or other works for withdrawal of groundwater 1941

8. The depth of water table 45 ~~XX~~ feet

9. So far as it may be available, the type, size and depth of each well or the general specifications of any other works for the withdrawal of groundwater 6" casing 70' depth

10. The estimated amount of groundwater withdrawn each year 900,000

11. The log of formations encountered in the drilling of each well if available Not Avaliable

12. Such other information of a similar nature as may be useful in carrying out the policy of this act, including reference to book and page of any county record None

Signature of Owner Henry Foos

Date December 10, 1962

Three copies to be filed by the owner with the County Clerk and Recorder of the county in which the well is located.

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

Original to the County Clerk and Recorder; duplicate to the State Engineer; Triplicate to the School of Mines and Quadruplicate for the Appropriator.

lings

Form No. 603 (R 6-84)

Bottled water Bathroom

131 grain hardness → soften to 30

Yellowstone

File No. 057728

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name FRANK FELKE

2. CURRENT MAILING ADDRESS
4417 HARVEST LANE
BILLINGS, MT 59106

3. WELL LOCATION
County YELLOWSTONE
Township 1 N/[✓ S] Range 24 [✓ E]/W
1/4 E½-SE¼ Section 33
Lot ______ Block ______
Subdivision LAUREL AIRPORT

4. PROPOSED USE Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify ______

5. DRILLING METHOD ______ cable, ______ bored,
X forward rotary, ______ reverse rotary, ______ jetted,
______ other (specify) ______

6. WELL CONSTRUCTION AND COMPLETION

Perforations 1/4 INCH and/or Screen ______

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Kind Size	From (feet)	To (feet)
7/8"	6 5/8" 1/4 WALL STEEL	0'	15'			
7/8"	6" PVC 160PSI	15'	98'	1/4" x 12 PER FOOT	60'	98'

Was casing left open end? ______ Yes X No
Was a packer or seal used? X Yes ______ No
If so, what material CEMENT @ 15'-SURFACE
Was the well gravel packed? X Yes ______ No
Was the well grouted? X Yes ______ No
To what depth? 15' – 60'
Material used in grouting BENTONITE SLURRY
Well head completion: Pitless adapter X Yes ______ No
Top of casing 12 in. or greater above grade X Yes ______ No

7. WHAT IS THE TEMPERATURE OF THE WATER?
45° Degrees Fahrenheit
☐ Measured ☒ Estimated

8. WATER LEVEL
Static water level 48' feet below land surface
If flowing; closed-in pressure ______ psi
______ gpm
Controlled by: ______ valve, ______ reducers,
______ other, (specify) ______

9. WELL TEST DATA ______ pump ______ bailer
______ other, (specify) AIR PUMP
Pumping water level below land surface:
60 ft. after 1 hrs. pumping 40 gpm
60 ft. after 2½ hrs. pumping 40 gpm

10. WAS WELL PLUGGED OR ABANDONED? ______ Yes X No
If yes, how? ______

11. DATE COMPLETED ______

12. WELL LOG

Depth (ft.) From	To	Formation
0'	30'	SOIL, SHALE GRAVEL
30'	90'	ALTERNATING SHALE AND GRAVEL, VERY LITTLE SAND

RECEIVED
SEP 25 1986
DEPT. OF NATURAL RESOURCES AND CONSERVATION
BILLINGS OFFICE

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

9-1-86
Date

SWEETWATER DRLG & EXPLORATION
Firm Name

BOX 123, BILLINGS, MT 59103
Address

Tod H Willis
Signature

468
License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION **DNRC**

32 SOUTH EWING HELENA, MONTANA 59620 444-6610

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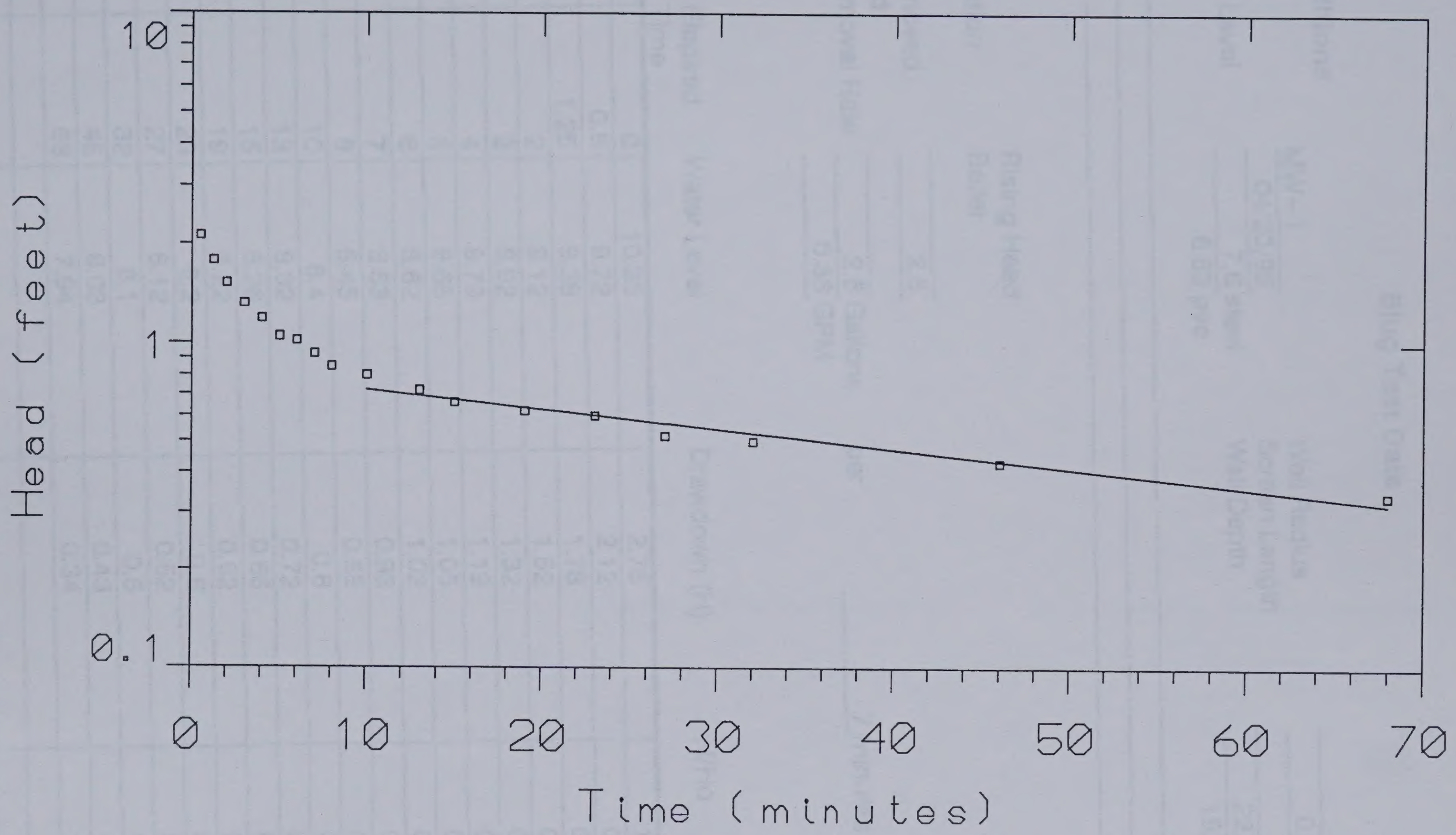
DEPARTMENT - BUREAU COPY

APPENDIX C

SLUG TEST DATA AND CALCULATIONS



MODEL TYPE: BOUWER and RICE

CONDUCTIVITY: .07098 ft/day

TRANSMISSIVITY: 2.129 sq. ft/day

INITIAL HEAD: 2.750 ft

Data Set: LAUREL

Date: 20-APR-95

for: CITY OF LAUREL

by: Chen-Northern

WELL DATA: Units: ft

AQUIFER: NIOBRARA SHALE

THICKNESS: 30.00

SCREEN: top: 15.00 base: 20.00

DIAMETER: casing: .1660 intake: .5000

DEPTH: Water Table: 5.030 TD: 20.00

LAUREL LANDFILL

Well: MW-1

LAUREL, MT

YELLOWSTONE COUNTY

Slug Test Data

Initial Conditions

Well MW-1
Date 04/20/95
Static Water Level 7.6 steel
6.53 pvc
Well Radius 0.08 ft
Screen Length 5 ft
Well Depth 22.34 steel
19.53 ground

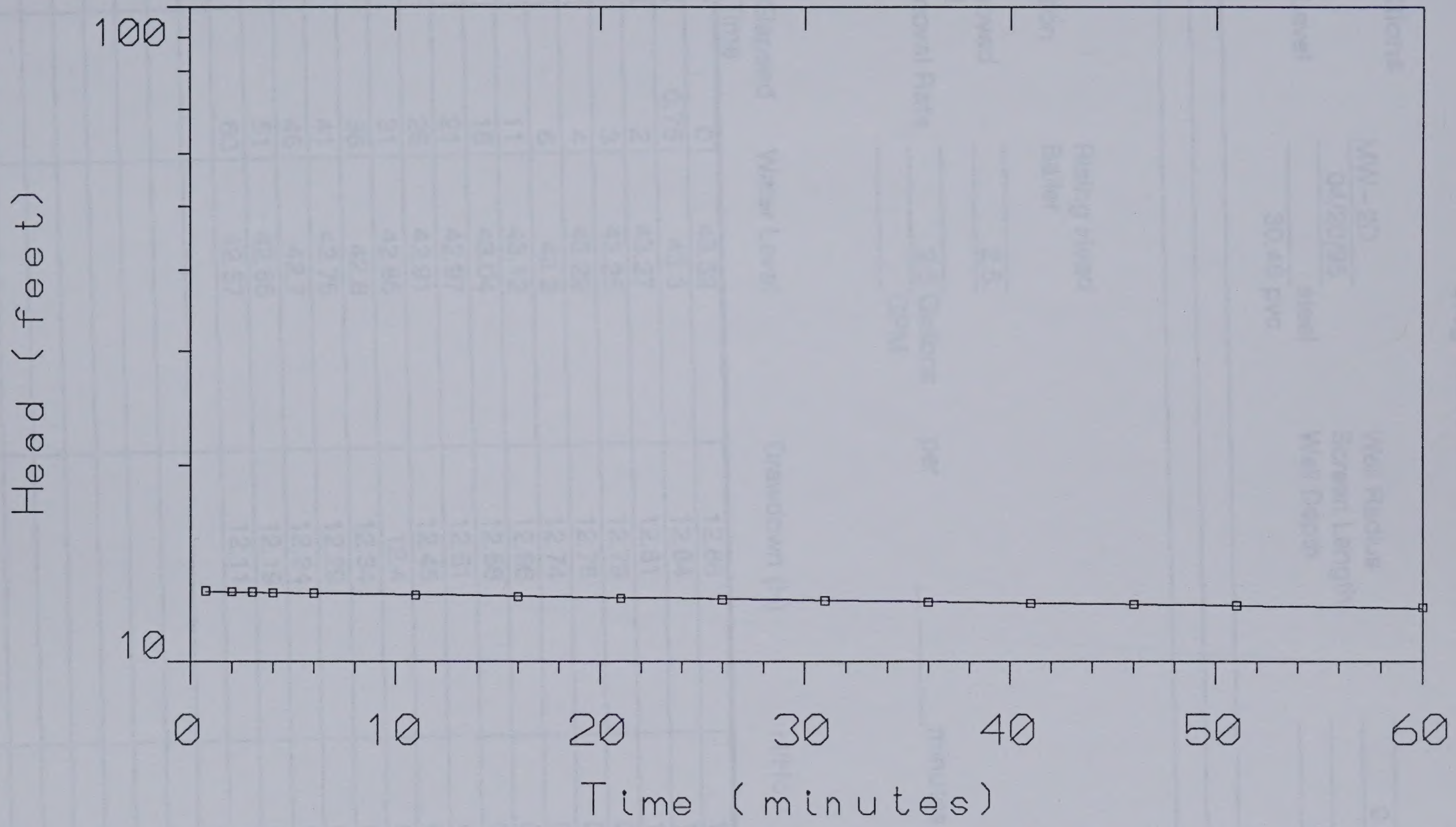
Comments

Slug

Test Type Rising Head
Well Evacuation Bailer
Time Start
Gallons Removed 2.5
Time Stoped
Average Removal Rate 2.5 Gallons per 7 minutes
0.36 GPM

Recovery

Time	Elapsed Time	Water Level	Drawdown (H)	H/Ho
	0	10.35	2.75	1.00
	0.5	9.72	2.12	0.77
	1.25	9.38	1.78	0.65
	2	9.12	1.52	0.55
	3	8.92	1.32	0.48
	4	8.79	1.19	0.43
	5	8.65	1.05	0.38
	6	8.62	1.02	0.37
	7	8.53	0.93	0.34
	8	8.45	0.85	0.31
	10	8.4	0.8	0.29
	13	8.32	0.72	0.26
	15	8.26	0.66	0.24
	19	8.22	0.62	0.23
	23	8.2	0.6	0.22
	27	8.12	0.52	0.19
	32	8.1	0.5	0.18
	46	8.03	0.43	0.16
	68	7.94	0.34	0.12



MODEL TYPE: BOUWER and RICE

CONDUCTIVITY: .0008859 ft/day

TRANSMISSIVITY: .07973 sq. ft/day

INITIAL HEAD: 12.86 ft

Data Set: LAUREL

Date: 20-APR-95

for: CITY OF LAUREL

by: Chen-Northern

WELL DATA: Units: ft
AQUIFER: NIOBRARA SHALE
THICKNESS: 90.00
SCREEN: top: 60.00 base: 80.00
DIAMETER: casing: .1660 intake: .5000
DEPTH: Water Table: 28.96 TD: 80.00

LAUREL LANDFILL

Well: MW-2D
LAUREL, MT
YELLOWSTONE COUNTY

Slug Test Data

Initial Conditions

Well MW–2D

Date 04/20/95

Static Water Level ______ steel

30.46 pvc

Well Radius 0.08 ft

Screen Length 10 ft

Well Depth 80

Comments ______

Slug

Test Type Rising Head

Well Evacuation Bailer

Time Start ______

Gallons Removed 2.5

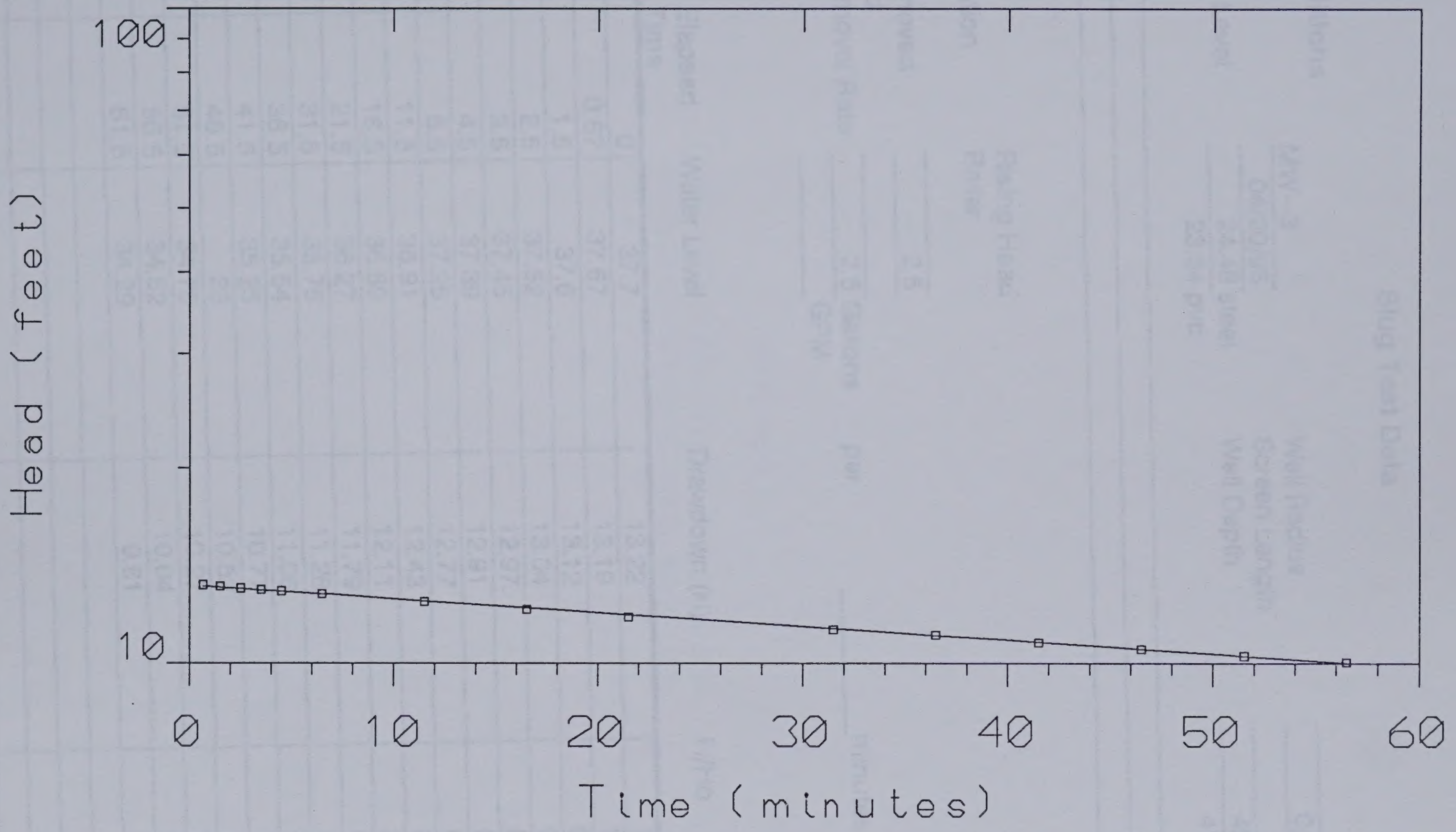
Time Stoped ______

Average Removal Rate 2.5 Gallons per ______ minutes

______ GPM

Recovery

Time	Elapsed Time	Water Level	Drawdown (H)	H/Ho
	0	43.32	12.86	1.00
	0.75	43.3	12.84	1.00
	2	43.27	12.81	1.00
	3	43.25	12.79	0.99
	4	43.22	12.76	0.99
	6	43.2	12.74	0.99
	11	43.12	12.66	0.98
	16	43.04	12.58	0.98
	21	42.97	12.51	0.97
	26	42.91	12.45	0.97
	31	42.86	12.4	0.96
	36	42.8	12.34	0.96
	41	42.75	12.29	0.96
	46	42.7	12.24	0.95
	51	42.65	12.19	0.95
	60	42.57	12.11	0.94



MODEL TYPE: BOUWER and RICE

CONDUCTIVITY: .01108 ft/day

TRANSMISSIVITY: .5651 sq. ft/day

INITIAL HEAD: 13.22 ft

Data Set: LAUREL
Date: 20-APR-95

for: CITY OF LAUREL
by: Chen-Northern

WELL DATA: Units: ft
AQUIFER: NIOBRARA SHALE
THICKNESS: 51.00
SCREEN: top: 36.00 base: 41.00
DIAMETER: casing: .1660 intake: .5000
DEPTH: Water Table: 21.84 TD: 41.00

LAUREL LANDFILL

Well: MW-3
LAUREL, MT
YELLOWSTONE COUNTY

Slug Test Data

Initial Conditions

Well MW-3
Date 04/20/95
Static Water Level 24.48 steel
23.34 pvc
Well Radius 0.08 ft
Screen Length 5 ft
Well Depth 43.8 steel
41.1 ground

Comments

Slug

Test Type Rising Head
Well Evacuation Bailer
Time Start
Gallons Removed 2.5
Time Stoped
Average Removal Rate 2.5 Gallons per minutes
GPM

Recovery

Time	Elapsed Time	Water Level	Drawdown (H)	H/Ho
	0	37.7	13.22	1.00
	0.67	37.67	13.19	1.00
	1.5	37.6	13.12	0.99
	2.5	37.52	13.04	0.99
	3.5	37.45	12.97	0.98
	4.5	37.39	12.91	0.98
	6.5	37.25	12.77	0.97
	11.5	36.91	12.43	0.94
	16.5	36.59	12.11	0.92
	21.5	36.27	11.79	0.89
	31.5	35.76	11.28	0.85
	36.5	35.54	11.06	0.84
	41.5	35.25	10.77	0.81
	46.5	35	10.52	0.80
	51.5	34.75	10.27	0.78
	56.5	34.52	10.04	0.76
	61.5	34.29	9.81	0.74

APPENDIX D

LABORATORY ANALYTICAL RESULTS FOR SELECTED DOMESTIC WELL SAMPLES

Huntingdon
(Formerly Chen-Northern, Inc.)
600 South 25th Street
P O Box 30615
Billings, MT 59107
(406) 248-9161
FAX (406) 248-9282

TECHNICAL REPORT

REPORT TO: ATTN: JEFF RICE
HUNTINGDON ENGINEERING &
ENVIRONMENTAL, INC.
P O BOX 30615
BILLINGS MT 59107

DATE: May 2, 1995
JOB NUMBER: 87-910
SHEET: 1 of 10
INVOICE NO.: 029423

REPORT OF: Water and Soil Analysis - Laurel Landfill

SAMPLE IDENTIFICATION:

On April 13, 1995, these water and soil samples (laboratory numbers 161977 through 161985) were received in our laboratory for analysis. Tests were conducted in accordance with the U.S. Environmental Protection Agency Manual EPA 600/4-79-020 *"Methods for Chemical Analysis of Water and Wastes"*. Soil analysis was performed using American Society of Agronomy methods by our laboratory in Houston, Texas.

The condition of the samples upon receipt at the laboratory is noted on the attached sample receipt checklist. Chain of custody documentation is enclosed.

The test results are shown on the following pages.

Reviewed by

Attachments: Sample Receipt Checklist
Chain of Custody

rmr

As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of our clients and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval. Test results apply specifically to the samples tested only. Samples will be disposed of after testing is completed unless other arrangements are agreed to in writing.

Client Name: HUNTINGDON - BILLINGS, MT
Project No.: 87-910
Laboratory No.: 161977
Sample Name: NORTH DUGOUT
Sample Date: 04/13/95
Collected by: JEFF RICE
Time Sampled: 1100
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Sulfate as SO4	5000	mg/l	375.2	04/20/95
INORGANICS				
Electrical Conductivity	6370	umhos/cm	120.1	04/27/95
pH	8.4	S.U.	150.1	04/13/95

Client Name: HUNTINGDON - BILLINGS, MT
Project No.: 87-910
Laboratory No.: 161978
Sample Name: FOOS WELL
Sample Date: 04/13/95
Collected by: JEFF RICE
Time Sampled: 1300
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Sulfate as SO4	1280	mg/l	375.2	04/20/95
INORGANICS				
Electrical Conductivity	2100	umhos/cm	120.1	04/27/95
pH	8.1	S.U.	150.1	04/13/95

Client Name: HUNTINGDON - BILLINGS, MT
Project No.: 87-910
Laboratory No.: 161979
Sample Name: FELKE WELL
Sample Date: 04/13/95
Collected by: JEFF RICE
Time Sampled: 1315
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Sulfate as SO4	2040	mg/l	375.2	04/20/95
INORGANICS				
Electrical Conductivity	7070	umhos/cm	120.1	04/27/95
pH	8.2	S.U.	150.1	04/13/95

Client Name: HUNTINGDON - BILLINGS, MT
Project No.: 87-910
Laboratory No.: 161980
Sample Name: TOP HAND WELL
Sample Date: 04/13/95
Collected by: JEFF RICE
Time Sampled: 1330
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Sulfate as SO4	986	mg/l	375.2	04/20/95
INORGANICS				
Electrical Conductivity	1850	umhos/cm	120.1	04/27/95
pH	8.1	S.U.	150.1	04/13/95

Client Name: HUNTINGDON - BILLINGS, MT
Project No.: 87-910
Laboratory No.: 161981
Sample Name: NORTHERN SKY
Sample Date: 04/13/95
Collected by: JEFF RICE
Time Sampled: 1340
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Sulfate as SO4	1370	mg/l	375.2	04/20/95
INORGANICS				
Electrical Conductivity	2330	umhos/cm	120.1	04/27/95
pH	8.0	S.U.	150.1	04/13/95

Client Name: HUNTINGDON - BILLINGS, MT
Project No.: 87-910
Laboratory No.: 161982
Sample Name: FOX
Sample Date: 04/13/95
Collected by: JEFF RICE
Time Sampled: 1400
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Sulfate as SO4	919	mg/l	375.2	04/20/95
INORGANICS				
Electrical Conductivity	996	umhos/cm	120.1	04/27/95
pH	8.0	S.U.	150.1	04/13/95

Client Name: HUNTINGDON - BILLINGS, MT
Project No.: 87-910
Laboratory No.: 161983
Sample Name: LAUREL LANDFILL CUT
Sample Date: 04/13/95
Collected by: JEFF RICE
Time Sampled: 1115
Sample Type: SOIL

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ORGANICS				
Total Organic Carbon	0.3521	%	9.90.2-6	04/24/95

Client Name: HUNTINGDON - BILLINGS, MT
Project No.: 87-910
Laboratory No.: 161984
Sample Name: DUPLICATE 161977 NORTH DUGOUT
Sample Date: 04/13/95
Collected by: JEFF RICE
Time Sampled: 1100
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Sulfate as SO4	5080	mg/l	375.2	04/20/95
INORGANICS				
Electrical Conductivity	6320	umhos/cm	120.1	04/27/95
pH	8.3	s.u.	150.1	04/13/95

Client Name:	HUNTINGDON - BILLINGS, MT
Project No.:	87-910
Laboratory No.:	161985
Sample Name:	SPIKE 161981 NORTHERN SKY
Sample Date:	04/13/95
Collected by:	JEFF RICE
Time Sampled:	1340
Sample Type:	WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Sulfate as SO4	102	%	375.2	04/20/95

ATTACHMENTS

Huntingdon

receipt.lst

SAMPLE RECEIPT CHECKLIST

Client Name: H-Blg
Project: Laurel Landfill
Laboratory number(s): 161977-83
Checklist completed by: GC / 4/13 (Initials / Date)

Date/Time Received: 4/13/95 / 1510 (Date / Time)
Received by: G Cleveland
Carrier name: Hand Delivered
Logged in by: GC / 4/13 (Initials / Date)
Sample Type: Water/Soil

YES NO

1. Shipping container in good condition? NA
2. Custody seals present on shipping container? NA
3. Condition: Intact ____ Broken ____
4. Chain of custody present? [✓ YES] NO
5. Chain of custody signed when relinquished and received? [✓ YES] NO
6. Chain of custody agrees with sample labels? [✓ YES] NO
7. Custody seals on sample bottles? YES [✓ NO]
8. Condition: Intact ____ Broken ____
9. Samples in proper container/bottle? [✓ YES] NO
10. Samples intact? [✓ YES] NO
11. Sufficient sample volume for indicated test? [✓ YES] NO
12. VOA vials have zero headspace? NA
13. Trip Blank received? YES [✓ NO]
14. Ice/Frozen Blue Ice present in shipping container? (circle one) NA
15. Container temperature 1. ____ 2. ____ 3. ____

YES NO

16. All samples rec'd within holding time? [✓ YES] NO

Preservation

17. pH check performed by: ____
18. Metals bottle(s) pH <2? NA
19. Nutrient bottle(s) pH <2? ___ ___
20. Cyanide bottle(s) pH >12? ___ ___
21. Sulfide bottle(s) pH >9? ___ ___
22. Oil & grease bottle(s) pH <2? ___ ___
23. TOC bottle(s) pH <2? ___ ___
24. DRO/418.1 bottle(s) pH <2? ___ ___
25. Phenolics bottle(s) pH <2? ___ ___
26. Volatiles (VOA) pH <2? (VOA pH checked by analyst) ___ ___
27. Client contacted? ___ ___
28. Person contacted ____
29. Date contacted ____
30. Contacted by ____
31. Regarding? ____

Any NO response must be detailed in the comments section below. If items are not applicable, they should be marked NA.

COMMENTS: ____

CHAIN OF CUSTODY RECORD

Huntingdon
Consulting Engineers · Environmental Scientists

Project or Site Name: Laurel landFill

Project Number: 94-3754-3

Sampler Name (Printed): Jeff Rice

☐ Chen-Northern, Inc., Division
☐ Thomas-Hartig & Associates, Inc., Division
☐ Schaefer Dixon Associates, Inc., Division
☐ Herzog Associates, Inc., Division

Contact or Report to: SAME ~~E.C.~~ Peter Dunlavy

Contact Address or Location:

Sampler Signature:

DATE COLLECTED	TIME COLLECTED	SAMPLE LOCATION OR DESCRIPTION	COMP OR GRAB	SAMPLE MATRIX	NO. OF CONTAINERS	ANALYSIS REQUIRED: SC	pH	~~#~~ Sulfates	TOC				NOTES	LAB NUMBER
4/13/95	11:00	North dugout	Grab	water	1	✓	✓	✓						161977
"	13:00	Foos well	"	"	1	✓	✓	✓						78
"	13:15	Felke well	"	"	1	✓	✓	✓						79
"	13:30	Top Hand well	"	"	1	✓	✓	✓						80
"	13:40	Northern Sky	"	"	1	✓	✓	✓						81
"	14:00	Fox	"	"	1	✓	✓	✓						82
"	11:15	Laurel ~~Lattle~~ Lanfill cut	~~soil~~ "	Soil	1				✓					83
													Dp 161977 Northdugout 4/13 1100	84
													Sp 161981 Northern Sky ↓ 1340	85

Relinquished by:	Date	Time	Received by:
	4/13/95	15:10	

Remarks:

CHAIN OF CUSTODY RECORD

Huntingdon

Consulting Engineers · Environmental Scientists

Laurel landfill
Project or Site Name

94-3754-3
Project Number

Jeff Rice
Sampler Name (Printed)

☐ Chen-Northern, Inc., Division
☐ Thomas-Hartig & Associates, Inc., Division
☐ Schaefer Dixon Associates, Inc., Division
☐ Herzog Associates, Inc., Division

SAME cc Pete Dunlavy
Contact or Report to

Contact Address or Location

Sampler Signature

DATE COLLECTED	TIME COLLECTED	SAMPLE LOCATION OR DESCRIPTION	COMP OR GRAB	SAMPLE MATRIX	NO. OF CONTAINERS	ANALYSIS REQUIRED SC	PH	#Sulfates	TOC				NOTES	LAB NUMBER
4/13/95	11:00	North dugout	Grab	water	1	✓	✓	✓						161977
"	13:00	Foos well	"	"	1	✓	✓	✓						78
"	13:15	Felke well	"	"	1	✓	✓	✓						79
"	13:30	Top Hand well	"	"	1	✓	✓	✓						80
"	13:40	Northern Sky	"	"	1	✓	✓	✓						81
"	14:00	Fox	"	"	1	✓	✓	✓						82
"	11:15	Laurel ~~Lattle~~ Lanfill cut	" ~~Soil~~	Soil	1				✓					83
										DP	161977		North dugout 4/13	1100 84
										SP	161981		Northern Sky ↓	1340 85

Relinquished by: Jeff Rice	Date 4/13/95	Time 15:10	Received by:	Remarks:
Relinquished by:	Date	Time	Received by:	
Relinquished by:	Date	Time	Received by:	
Relinquished by:	Date	Time	Received by:	

GEORESEARCH, INC.

DRAFT

Hydrogeological and Soils Study

City of Laurel Landfill (License #203)

RECEIVED

FEB 1 4 1994

MONTANA [illegible]
AND ENVIRONMENTAL SCIENCES
HAZARDOUS WASTE BUREAU

GEO
RESEARCH®

DRAFT

Hydrogeological and Soils Study

City of Laurel Landfill
(License #203)

RECEIVED

FEB 14 1994

MONTANA [illegible]
AND ENVIRONMENTAL SCIENCES
[illegible] HAZARDOUS WASTE BURE

Hydrogeological
and Soils Study

at the
City of Laurel Landfill
(License #203)

Prepared for:

City of Laurel
P.O. Box 10
Laurel, Montana 59044

Prepared by:

GeoResearch, Inc.
115 North Broadway
Billings, Montana 59101
(406) 248-6771

February 9, 1994

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1.0 INTRODUCTION

This report presents the findings of GeoResearch's Hydrogeological and Soils Study at the Laurel Landfill License #203 north of Laurel, Montana. This investigation was initiated in response to a request by the Montana Solid Waste Program (MSWP) dated May 8, 1992, concerning the status of the site. Among other tasks, the letter required the City to conduct a hydrogeological and soils study and also to monitor groundwater. The specific requirements for conducting the study are described in Subchapter 7 of Title 16, Chapter 14 of the Administrative Rules of Montana.

1.1 Scope of Work

The Work Plan for the initial hydrogeological and soils investigation was dated September 4, 1992 (GeoResearch, 1992a) through a review and response process between MSWP and GeoResearch. A final work plan and investigations scope were defined and approved by the MSWP on October 26, 1992. Field work was conducted during October and November 1992. The results, evaluation findings, and conclusions of the investigation were presented in a report dated December 31, 1992, (GeoResearch, 1992c). This report presents the 1992 information and includes the results of additional site work conducted in response to comments on the December 1992 study (considered a status report by the MSWP) from MSWP, dated March 29 and June 23, 1993. A brief outline of the additional work that was to be performed in conducting the 1993 investigations was presented to the MSWP in letters dated July 1, and August 24, 1993. Development of the scope for the 1992 and 1993 investigations includes the following correspondence:

- Work Plan for a Hydrogeological and Soils Investigation
  at the City of Laurel Landfill
  Dated: September 4, 1992
  Prepared by: GeoResearch, Inc.

- Laurel Class II Landfill, Yellowstone County, License No. 203
  Review of the Workplan for the Hydrogeological and Soils Study
  Dated: October 6, 1992
  Prepared by: Solid Waste Program

- Response to Review of the Work Plan for the
  Hydrogeological and Soils Study
  Dated: October 14, 1992
  Prepared by: GeoResearch, Inc.

- Requirements for Approval of the Workplan for the
  Laurel Class II Landfill, Yellowstone County, License No. 203

Dated: October 21, 1992
Prepared by: Solid Waste Program

- Response to Comments Concerning the Work Plan for a Hydrogeological and Soils Investigation at the City of Laurel Landfill
  Dated: October 26, 1992
  Prepared by: GeoResearch, Inc.

- Approval of the Workplan for Laurel Landfill Yellowstone County, License No. 203
  Dated: October 26, 1992
  Prepared by: Solid Waste Program

- Laurel Class II Landfill, Yellowstone County, License No. 203 Review of the Hydrogeological and Soils Study
  Dated: March 29, 1993
  Prepared by: Solid Waste Program

- Groundwater Monitoring at Laurel Landfill
  Dated: June 10, 1993
  Prepared by: GeoResearch, Inc.

- Laurel Class II Landfill, Yellowstone County, License No. 203 Review and Comments on May, 1993 Groundwater Sampling Event, and Finalization of Hydrogeological and Soils Report
  Dated: June 23, 1993
  Prepared by: Solid Waste Program

- Laurel Class II Landfill, Yellowstone County - License No. 203 Response to Review Comments Dated June 23, 1993
  Dated: July 1, 1993
  Prepared by: GeoResearch, Inc.

- Laurel Class II Landfill, Yellowstone County - License No. 203 (Modification of Calculations presented on July 1, 1993)
  Dated: August 24, 1993
  Prepared by: GeoResearch,Inc.

The 1992 investigation included drilling of test borings, monitoring well construction and development, and hydraulic conductivity testing of aquifer and vadose zone materials, and collection and analysis of groundwater samples. Specifically, the site investigation included:

- Drilling four test borings to groundwater;

- Drilling one test boring for hydraulic conductivity testing;
- Hand-augering three borings for hydraulic conductivity testing;
- Six laboratory tests on soil samples;
- Completing four monitoring wells;
- Completing one permeability test well;
- Developing the monitoring wells;
- Conducting six aquifer tests;
- Conducting four unsaturated permeability tests;
- Sampling and analyzing six groundwater samples; and
- Preparing a report.

The additional investigation conducted during 1993, the results of which are evaluated in this report, included:

- Drilling one test boring to the second water bearing zone;
- Resuming measurements for hydraulic conductivity testing in the existing test well;
- Backhoe excavation and hand-auguring three borings to ten feet below ground surface for unsaturated hydraulic conductivity testing;
- Completing one monitoring well;
- Conducting one aquifer test;
- Conducting one pump test
- Two groundwater quality sampling and analysis events;
- Initiation of 12 consecutive monthly groundwater level measurements; and
- Preparation of a final report.

2.0 SITE DESCRIPTION

2.1 General Description

The Laurel Landfill is located on Buffalo Trail (State Route 532) approximately one and one half miles north of Laurel on property owned by the Montana Department of State Lands and operated by the City of Laurel under a right-of-way easement. A vicinity map showing the location of the site is presented on Figure 2-1. The site consists of several adjacent parcels totaling approximately 40 acres. The landfill under study consists of 10.02 acres located in the northwest quarter of Section 33, Township 1 South, Range 24 East. This final parcel was licensed in 1982 as an expansion to a ten acre site also located in the northwest quarter of Section 33 which received License #24 in 1978 (Figure 2-2). This investigation specifically addresses the final site, License #203, which was in operation in October, 1989. The older site immediately to the north (License #24) was closed in 1983 and §75.10.204(5) MCA does not apply; therefore, an investigation of this site is not required.

According to file information obtained from MSWP, a dump site was opened in 1965 in the vicinity of the other sites. This dump probably corresponds to two additional fill areas which were identified in the field. One site is located adjacent to the License #24 site and is bounded on the north side by a diversion ditch. This site has been covered and fenced and presently has a poor stand of grass on the cover. Northeast of these landfill sites along the north line of Section 33 is a dump area which contains buried waste and a ridge of soil which may have been a stockpile of cover material or topsoil. The approximate relative locations of these sites are presented on Figure 2-2.

For the purposes of this report, "site" refers to the final site covered by License #203, a 10.02 acre facility.

2.2 Site Topography

The site is located on colluvial uplands above the Yellowstone Valley. Prior to landfilling, the topography was gently sloping toward the southeast with shallow swales draining the central area of the site to a more defined swale which generally followed the east boundary and exited toward the southeast. The site was covered with waste to the approximate boundaries. The final cover consisting of 18 inches of lean clay topped with 6 inches of top soil was applied in late 1992. Reseeding of the site was deferred until after the 1993 field investigation. However, a late harvest season and early winter weather caused the seeding subcontractor to postpone planting until spring 1994. Reseeding will be accomplished according to guidelines presented in the Closure Plan (GeoResearch, 1992b).

A drainage swale which drains a significant area is located along the north and east boundaries of an older landfill as shown in Figure 2-2. The older landfills have been graded to smooth, positively drained, gentle slopes with the highest points near the center. A final cover has been applied and vegetation has been established on the older landfills.

2.3 Areal Hydrogeology

Based on published hydrogeological mapping (Gosling and Pashley, 1973; Hutchinson, 1983), the surficial geological units in the vicinity of the site include alluvium and terrace deposits along the Yellowstone Valley and piedmont and slopewash deposits on the uplands near the site. Bedrock includes the Eagle formation which outcrops and forms vertical escarpments along the hills and ridges north of the site (Clapper Flats). The Eagle formation is underlain by the Telegraph Creek formation which also outcrops and forms larger hills north of the site. This is underlain by the Colorado Group (i.e., shale) which is further subdivided and includes the Niobrara formation in this area (Balster, 1971). The eroded low hills and stream valleys in the immediate vicinity of the landfill are in the Niobrara. A summary of the various hydrogeological units in the vicinity is presented in Table 2-1.

No major faulting or fracturing has been reported or mapped in the vicinity of the Laurel Landfill. Geologic structure is uncomplicated with stratigraphic units dipping moderately to the northwest at approximately three to six degrees.

According to well logs on record at the Montana Bureau of Mines and Geology in Butte, very few wells are located within one mile north, east, and west of the site. Two wells located north of the site encountered groundwater at depths of less than 30 feet. Numerous wells are located south of the site including several in the Beartooth and Groshelle Heights subdivisions (approximately one and one-quarter miles south-southeast). These wells encountered groundwater in gravel at depths ranging from 40 to 150 feet with most being between 80 and 110 feet deep. These wells are apparently completed in the alluvial gravels occurring throughout the Yellowstone River Valley. Based on the topography of the area, the general direction of groundwater movement is expected to be southeast toward the Yellowstone River. This concurs with the direction of flow in the Yellowstone Valley gravel unit (Gosling and Pashley, 1973; Hutchinson, 1983). The water table in the area is reported to fluctuate seasonally and with precipitation. Highest levels occur during the irrigation season and the lowest levels during winter and early spring. Precipitation in the Billings area is generally greatest during April, May, and peaking in June with a slight increase also during September (Gosling, 1973).

The nearest well to the southeast, located near the Laurel Municipal Airport, encountered groundwater at 60 feet in shale and gravel. Copies of driller's logs for selected nearby water wells are included in Appendix A. One stock well is reported

A drainage swale which drains a significant area is located along the north and east boundaries of an older landfill as shown in Figure 2-3. The older landfills have been graded to smooth, positively drained, gentle slopes with the highest points near the center. A final cover has been applied and vegetation has been established on the older landfills.

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Based on published hydrogeological mapping (Gosling and Pashley, 1973; Hutchinson, 1983), the surficial geological units in the vicinity of the site include alluvium and terrace deposits along the Yellowstone Valley and piedmont and slopewash deposits on the uplands near the site. Bedrock includes the Eagle formation which outcrops and forms vertical escarpments along the hills and ridges north of the site (Clapper Flats). The Eagle formation is underlain by the Telegraph Creek formation which also outcrops and forms larger hills north of the site. This is underlain by the Colorado Group (i.e., shale) which is further subdivided and includes the Niobrara formation in this area (Gelster, 1971). The eroded low hills and stream valleys in the immediate vicinity of the landfill are in the Niobrara. A summary of the various hydrogeological units in the vicinity is presented in Table 2-1.

No major faulting or fracturing has been reported or mapped in the vicinity of the Laurel Landfill. Geologic structure is uncomplicated with stratigraphic units dipping moderately to the northwest at approximately three to six degrees.

According to well logs on record at the Montana Bureau of Mines and Geology in Butte, very few wells are located within one mile north, east, and west of the site. Two wells located north of the site encountered groundwater at depths of less than 30 feet. Numerous wells are located south of the site including several in the Beartooth and Grosbelle Heights subdivisions (approximately one and one-quarter miles south-southeast). These wells encountered groundwater in gravel at depths ranging from 40 to 150 feet with most being between 80 and 110 feet deep. These wells are apparently completed in the alluvial gravels occurring throughout the Yellowstone River Valley. Based on the topography of the area, the general direction of groundwater movement is expected to be southeast toward the Yellowstone River. This concurs with the direction of flow in the Yellowstone Valley gravel unit (Gosling and Pashley, 1973; Hutchinson, 1983). The water table in the area is reported to fluctuate seasonally and with precipitation. Highest levels occur during the irrigation season and the lowest levels during winter and early spring. Precipitation in the Billings area is generally greatest during April, May, and peaking in June with a slight increase also during September (Gosling, 1973).

The nearest well to the southeast, located near the Laurel Municipal Airport, encountered groundwater at 60 feet in shale and gravel. Copies of driller's logs for selected nearby water wells are included in Appendix A. One stock well is reported to be completed in shale one-half mile southwest of the landfill. Figure 2-3 shows approximate locations of some of the water wells in the area and includes the interpretation of the regional flow of groundwater according to Hutchinson (1983).

Groundwater from bedrock sources usually contains significant concentrations of total dissolved solids and is high in sodium and sulfates. Concentrations of dissolved solids in groundwater within one mile downgradient (southeast) of the Laurel Landfill are projected in excess of 4,800 ppm (specific conductance $\geq$ 6,000 micromhos/cm @ 25° C, Hutchinson, 1983) and exhibit an increasing trend toward the landfill. The shallow groundwater in this area is classified as Class III (ARM 16.20.1002(1)(c)). As such, it may be suitable for some industrial and commercial uses including livestock watering and some irrigation purposes.

Operations information obtained for the site indicates that some groundwater seepage was detected during excavation of waste trenches. Additionally, a spring is located one-half mile northeast of the site. Seepage areas are located about one-third mile east of the site and an area containing efflorescence is located one-quarter mile south of the landfill. The efflorescence indicates seepage and evaporation of highly mineralized water. The locations of these areas are presented on Figure 2-2.

2.4 Climate

Climate in the Billings/Laurel area is classified as semi-arid and an average precipitation of 14 inches per year has been recorded by the National Weather Service at the Logan International Airport in Billings (National Climatic Data Center, 1992).

2.5 Closure Status

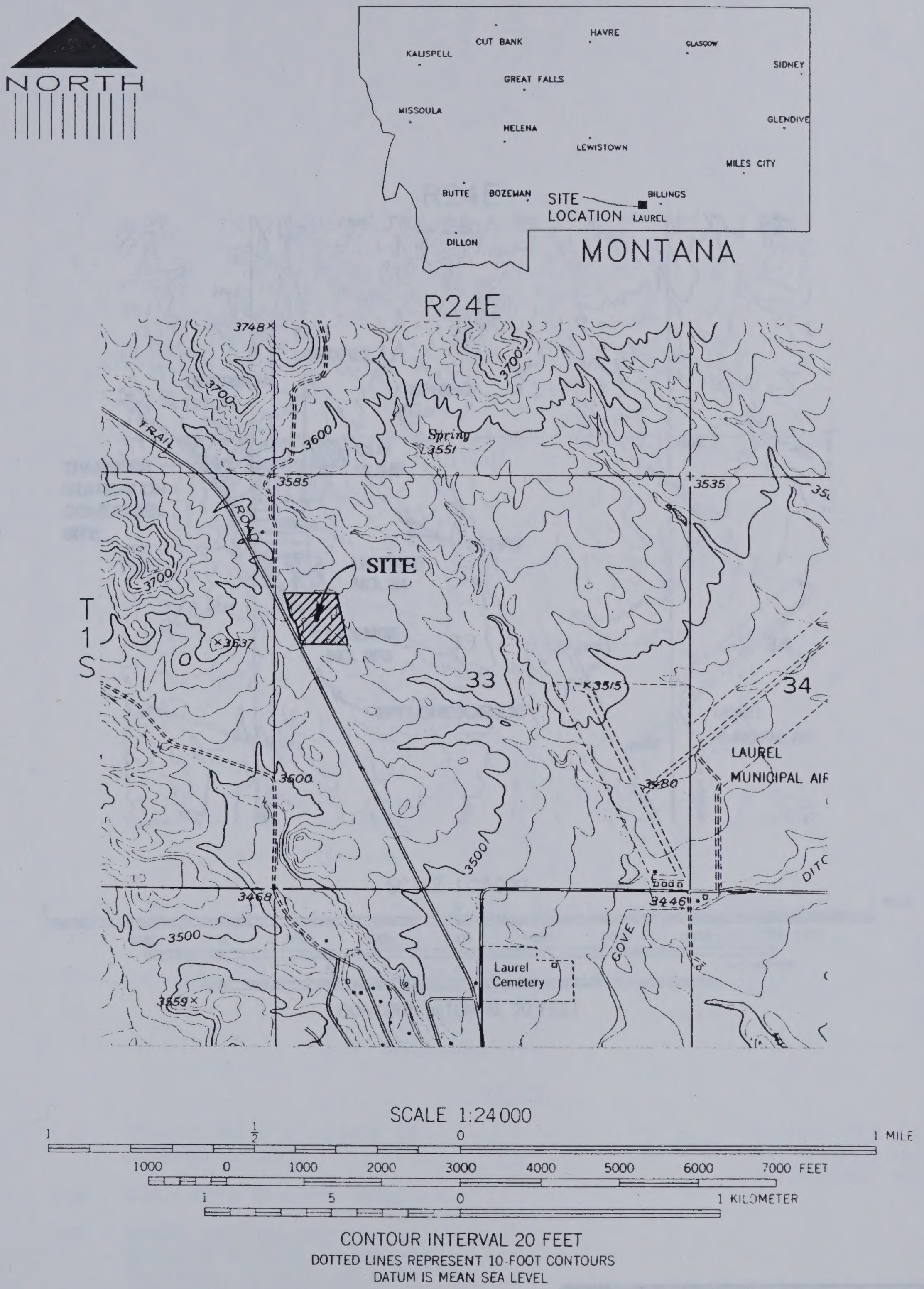
The Closure Plan was submitted to the Solid and Hazardous Waste Bureau and was approved on November 19, 1992. Mr. Craig Stagner of the MSWP completed the State closure inspection on June 21, 1993. Mr. Stagner noted the need to repair erosion channels, to reseed the site, to post "No Trespassing/No Dumping" signs in prominent locations, and to maintain access control. Upon completion of this work, the City of Laurel will surrender License #203 to complete the landfill closure.

Further information on site closure activities can be obtained in:

- Closure Plan, City of Laurel Landfill
  Dated: November 17, 1992
  Prepared by: GeoResearch, Inc.

- Closure Plan for the City of Laurel Class II Landfill #203
  Dated: November 19, 1992
  Prepared by: Solid Waste Program

- Closure Inspection of City of Laurel Class II Landfill #203
  Dated: August 23, 1993
  Prepared by: Solid Waste Program



GEO RESEARCH

FIGURE 2 –1

VICINITY MAP
CITY OF LAUREL LANDFILL
LAUREL, MONTANA

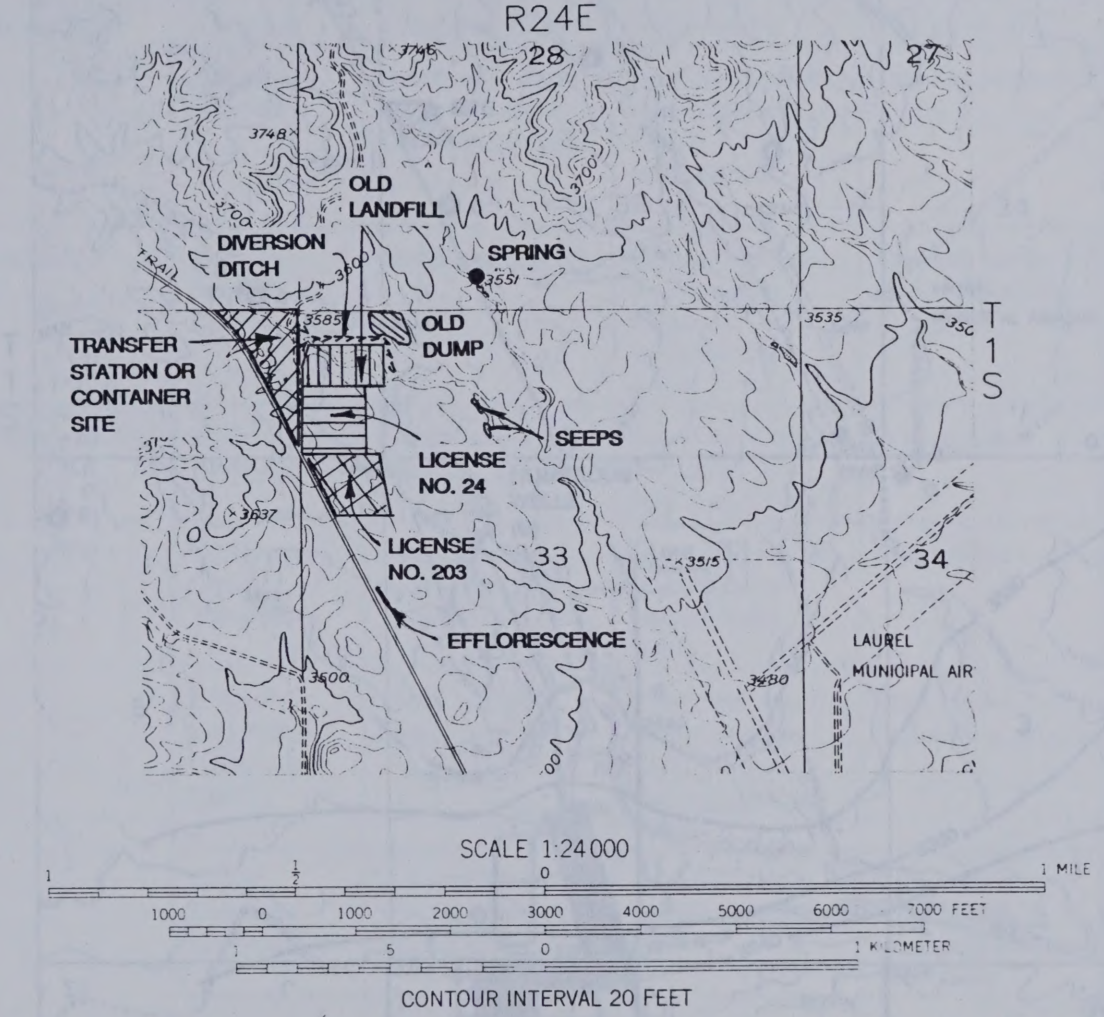


FIGURE 2-2

GENERAL SITE MAP
CITY OF LAUREL LANDFILL
LAUREL, MONTANA

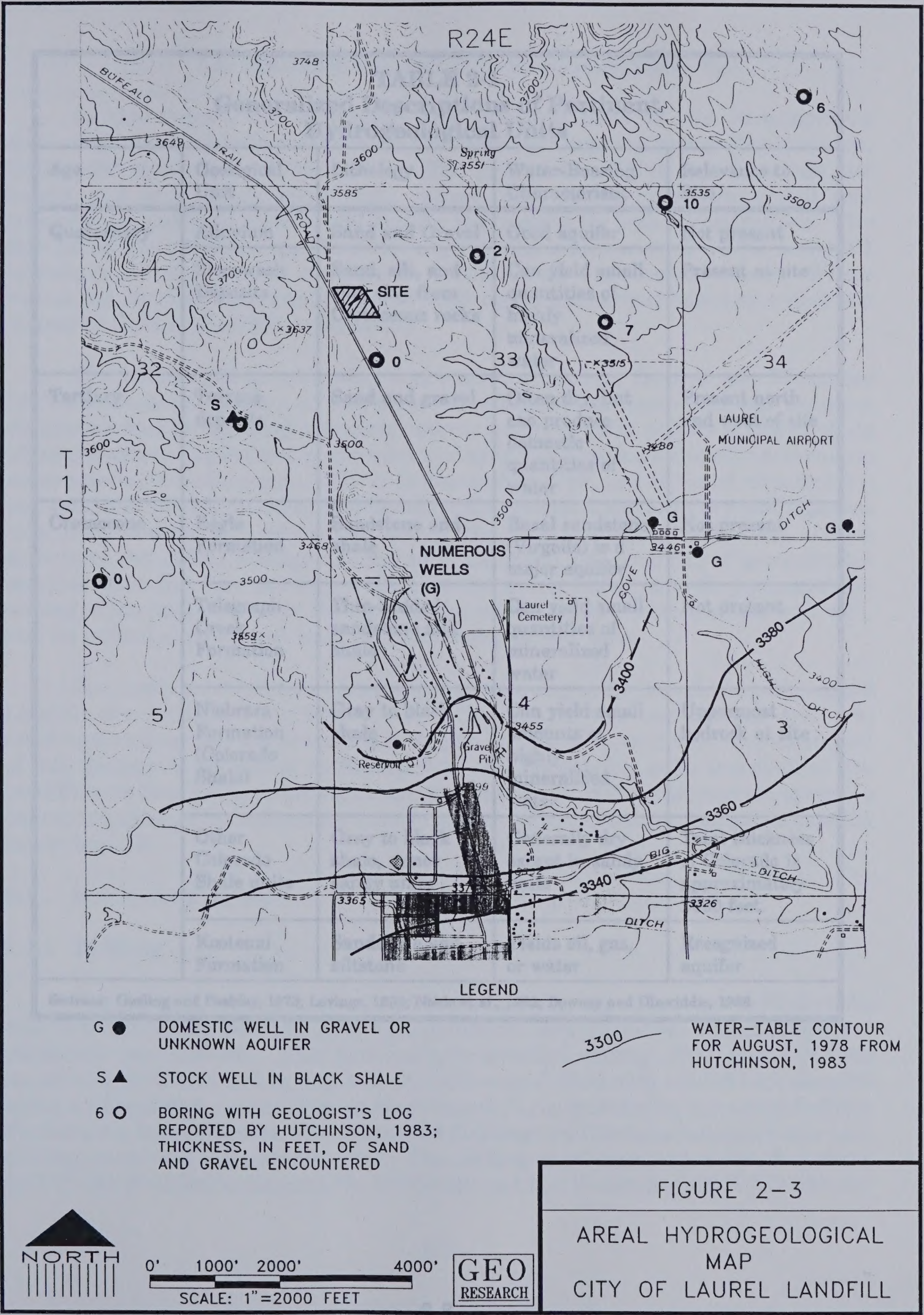


FIGURE 2-3

AREAL HYDROGEOLOGICAL MAP
CITY OF LAUREL LANDFILL

TABLE 2-1
Generalized Descriptions of Pertinent Hydrogeological Units

Age	Geological Unit	Lithology	Water-Bearing Characteristic	Relevance to Site
Quaternary	Alluvium	Sand and Gravel	Good aquifer	Not present
	Slopewash Deposits	Sand, silt, and silty clay from Cretaceous rocks	Can yield small quantities of highly mineralized water	Present at site
Tertiary	Terrace deposits	Sand and gravel	Often dry, but can produce domestic quantities of water	Present north and west of site
Cretaceous	Eagle Formation	Sandstone and shale	Basal sandstone (Virgelle) is a major aquifer	Not present
	Telegraph Creek Formation	Thin-bedded sandstone and shale	Can yield small quantities of mineralized water	Not present
	Niobrara Formation (Colorado Shale)	Gray to black shale	Can yield small amounts of highly mineralized water	Uppermost bedrock at site
	Other Colorado Shale units	Gray to black shale, minor sandy units	Generally dry except in sandy units	Total thickness of Colorado is approximately 2000 feet.
	Kootenai Formation	Sandstone and siltstone	Yields oil, gas, or water	Recognized aquifer

Sources: Gosling and Pashley, 1973; Levings, 1981; Noble et al., 1982; Downey and Dinwiddie, 1988

3.0 HYDROGEOLOGIC INVESTIGATION

In this report, the discussion and interpretations of the investigations conducted include details presented in the 1992 investigation report (GeoResearch, 1992c) and those of the 1993 studies. The appendices of this report include test boring and well construction logs, vadose zone study calculations, soil and groundwater analyses results, and aquifer test results for both investigations. The interpretations presented in the following sections summarize the 1992 and 1993 investigations and present conclusions based on all the available data. Where warranted, conclusions presented in the 1992 report are revised based on evaluation of data in light of the 1993 information.

The initial field investigation was performed during October and November 1992 and included drilling of test borings, collection and testing of soil samples, completion and development of groundwater monitoring wells, collection and analysis of groundwater samples, and performance of hydrologic testing on aquifer and vadose zone materials (GeoResearch, 1992c). In September 1993, an additional investigation was conducted which included installation and development of one deep well adjacent to a 1992 shallow well which had shown the presence of contamination. Other aspects of the 1993 investigation included collection and analysis of groundwater samples from the four existing wells and the newly installed well, hydrogeologic testing of the vadose zone at the base of the waste, aquifer testing of the new well, and an extended pump test involving all downgradient wells.

The locations of all test borings and monitoring wells installed at the Laurel Landfill are presented on Figure 3-1. The logs of the test borings and well construction diagrams are contained in Appendix B and Appendix E. A cross-section of site geology is presented in Figure 3-2. All monitoring wells installed at the landfill have been projected at right angles into the line of the cross-section to enable characterization of the subsurface stratigraphic and hydrogeologic conditions existing at the landfill.

3.1 Soil Investigation

3.1.1 Drilling

Test borings, subsequently completed as monitoring wells, were drilled at the site in order to describe the lithologic materials, soil moisture, and groundwater conditions encountered. The test borings installed during 1992 and the deep monitoring well installed in September, 1993 were drilled with a 5-7/8 inch drag bit using air circulation mounted on an air-rotary drill rig operated by Advanced Drilling Techniques, Inc., of Laurel, MT. Advanced Drilling is a Montana licensed water well drilling contractor (License No. 508). The drilling crew consisted of Mr. R. Lehner (MT Water Well Driller License No. WWD-39) and Mr. W. Jewitt (MT WWD-532 and

MT Water Well Constructor License No. 217). During drilling, the cuttings were continuously monitored and logged by a hydrogeologist.

Drill bits and rods were decontaminated prior to drilling on site and after drilling of each boring. Decontamination was completed using a hot water pressure washer and potable water; wash water was spread onto the landfill for disposal.

3.1.2 Soil and Rock Conditions

During the 1992 investigation, no municipal solid waste was encountered in any of the borings drilled except MW-1.

Boring MW-1 (1992) was drilled to a depth of 20 feet. This boring encountered one half foot of fat clay cover materials overlying solid waste to a depth of 2 feet. This was underlain by yellowish brown fat clay which was interpreted to be topsoil. This was underlain by brown lean clay to a depth of 6 feet. The basal unit encountered was dark brown shale with some gypsum flakes to the total depth drilled of 20 feet. The shale is believed to be weathered bedrock belonging to the Niobrara formation. The solid waste materials are suspected to be of windblown origin. Rationale for this conclusion is based on native soils encountered below the waste and the well's physical location at the extreme edge of the landfill property where burial of waste was unlikely.

MW-2 (1992) encountered yellowish brown lean clay to 3 feet followed by dark brown lean clay to 10 feet. Dark brown shale (bedrock) was then encountered to the total depth of 20 feet.

Test borings MW-3 and MW-4 (1992) also penetrated yellowish brown clay underlain by brown, lean clay which is underlain by dark brown shale; the uppermost bedrock lithology at these locations. Bedrock was encountered at depths of 6 and 12 feet below ground surface, respectively. In MW-3, black shale with traces of gypsum was encountered at 19 feet to the total drilling depth of 55 feet. In MW-4, similar black shale was penetrated at 27 feet to the total drilling depth of 32 feet.

The deep monitoring well, 93MW2-D, drilled during the September 1993 phase of the investigation, is located approximately 20 feet south of well MW-2. Drilling encountered gray clay and solid waste to a depth of 4 feet below ground surface; a strong sulphurous odor was also apparent at this depth. Those materials were underlain by tan sandy clay or dark brown sandy clay to a depth of 15 feet. This was underlain by olive gray to gray black clay, suspected weathered bedrock, from 15 to 25 feet. Dense shale of the Niobrara formation (Colorado Shale of upper Cretaceous age) was encountered from 25 feet to the total depth of 100 feet. Contrasting with the black shale, layers of light gray silty shale, possibly bentonite, were encountered at depths of 70 to 71 feet, 81 to 82 feet, and from 87.5 to 90 feet.

MT Water Well Contractor License No. 8129. During drilling, the cuttings were continuously monitored and logged by a hydrogeologist.

Drill bits and rods were decontaminated prior to drilling on site and after drilling of each boring. Decontamination was completed using a hot water pressure washer and potable water; wash water was spread onto the landfill for disposal.

2.1.2 Soil and Rock Conditions

During the 1992 investigation, no recognized solid waste was encountered in any of the borings drilled except MW-1.

Boring MW-1 (1992) was drilled to a depth of 29 feet. This boring encountered one half foot of fat clay cover materials overlying solid waste to a depth of 3 feet. This was underlain by yellowish brown fat clay which was interpreted to be natural. This was underlain by brown lean clay to a depth of 6 feet. The bedrock unit encountered was dark brown shale with some gypsum flakes to the total depth drilled of 29 feet. The shale is believed to be weathered bedrock belonging to the Niobrara formation. The solid waste materials are assumed to be of unknown origin. Rationale for this conclusion is based on native soils encountered below the waste and the well's physical location at the extreme edge of the landfill property where burial of waste was unlikely.

MW-2 (1992) encountered yellowish brown lean clay to 3 feet followed by dark brown lean clay to 20 feet. Black brown shale (bedrock) was then encountered to the total depth of 30 feet.

Test borings MW-3 and MW-4 (1992) also penetrated yellowish brown clay underlain by brown lean clay which is underlain by dark brown shale, the uppermost bedrock lithology at these locations. Bedrock was encountered at depths of 8 and 12 feet below ground surface, respectively. In MW-3, black shale with traces of gypsum was encountered at 19 feet to the total drilling depth of 28 feet. In MW-4, similar black shale was encountered at 27 feet to the total drilling depth of 32 feet.

The deep monitoring well "MW-2 D," drilled during the September 1993 phase of the investigation, is located approximately 20 feet south of well MW-2. Drilling encountered gray clay and solid waste to a depth of 8 feet below ground surface; a strong sulphurous odor was also apparent at this depth. These materials were underlain by lean sandy clay or dark brown sandy clay to a depth of 16 feet. This was underlain by olive gray to gray black clay, suspected weathered bedrock, from 16 to 25 feet. Dense shale of the Niobrara Formation (Colorado Shale) of Upper Cretaceous age was encountered from 25 feet to the total depth of 100 feet. Commencing with the black shale, layers of light gray silty shale, possibly bentonite, were encountered at depths of 70 to 71 feet, 81 to 82 feet, and from 87.5 to 90 feet.

Boring R-1 (1992) was drilled to a total depth of 7 feet and encountered only yellowish brown, dry, lean, fat clay belonging to the surface soil at this location. This boring was constructed as a single-ring infiltrometer to enable testing of the surface soils at the landfill.

Borings G-1, G-2, and G-3 (1992) were installed by hand-auguring methods for vadose zone investigation purposes (see Section 3.1.5). Borings G-1 and G-2 encountered yellowish brown fat clay to total depth of 1.67 and 2.58 feet, respectively. Boring G-3 encountered top soil and brown clay to 2.0 feet and weathered brown shale to its total depth of 2.67 feet.

Additional Guelph Permeameter test borings were installed at locations 93G-1, 93G-2, and 93G-3 for vadose zone investigation in 1993. Guelph holes were installed by hand augering to approximately 4 feet below the bottom of test pits excavated to 6 feet below land surface by a backhoe. This method tested strata at or below the level of buried solid waste at the test locations. Guelph holes 93G-1 and 93G-3 were installed to total depths of 10.0 and 9.9 feet below land surface, respectively. Tan and gray, clay was encountered in both holes to the total depth. Hole 93G-2 encountered brown, tan, and gray sandy clay mixed with solid waste to 2.4 feet; gray clay was present to a depth of 10 feet. After four days, groundwater had accumulated in the auger hole to a depth of 7.7 feet. A second test hole was then placed approximately 2 feet south of the first hole and was augured to a depth of 6.9 feet. Testing was then conducted in the second hole.

3.1.3 Soil Descriptions

According to the U.S. Department of Agriculture Soil Conservation Service (USDA/SCS, 1972) Soil Survey of Yellowstone County, the general soil map indicates the McRae-Lohmiller-Keiser association soils are present throughout the vicinity of the Laurel Landfill. Detailed soil map sheet #173 classifies the soil at the landfill as Clapper Gravelly Loam on the northern and eastern portions of the landfill. The majority of the landfill area occurs in the Midway Shale Outcrop Complex as shown on Figure 3-3.

The McRae-Lohmiller-Keiser Soil Association occurs on gently sloping to sloping sites consisting of terraces and fan deposits with grayish-brown deep loams to pale-yellow fine sandy loam to silty clays. These soils are generally found on high terraces and fans and underlain by clay to fine sandy loam.

Clapper Gravelly Loam (Cg) soils occur on deeply eroded gravel terraces on slopes of 7 to 15 percent and have moderate permeability, low available water capacity, and low salinity. Gravelly loam or clay loam is typically found to a depth of 13 inches and hard bedrock is found at depths greater than 60 inches. Its use as gravel is limited by the high content of calcareous fines. This soil typically contains

more than 20 percent coarse fragments. In-place permeability ranges from 0.63 - 2.0 inches per hour.

Midway-Shale Outcrop Complex soils (My) are typically composed of heavy clay loam and true shale to a depth of 12 inches with shale encountered at 12 inches. Hard shale bedrock is generally encountered at depths of 10 to 20 inches. This soil typically has a slow permeability (0.60 - 0.20 inches per hour) and intake rate. The areas contribute large amounts of rapid runoff, are susceptible to erosion and produce abundant silt where shale is exposed. The Yellowstone County Soil Survey indicates that this soil typically has no salinity. Areas of efflorescence have been observed in the vicinity south of the Laurel Landfill on lands mapped as this soil complex (compare Figures 2-2 and 3-3).

3.1.4 Soil Sample Laboratory Testing

General soil characteristics were determined from USDA/SCS data. Site specific data were obtained from soil samples collected in 1992 from surface locations L-1, L-2, and a subsurface sample from the 6 to 7 foot interval in R-1. Boring and sample locations are shown on Figure 3-1. Because of the shallow depth to bedrock at the site, few soil samples were collected. One sample from R-1 was analyzed for total organic carbon, pH, and moisture content. Sample L-1 consisted of surface clayey gravel and L-2 represents the clay soil borrowed from the general area and compacted for the landfill cap. These are samples of cover material collected for the landfill closure design.

Grain size distributions using sieve and hydrometer methods (ASTM D422 and ASTM D1140) were determined on all three of the above soil samples during the 1992 investigation. The results of grain size distribution analyses are summarized on Figure 3-4. Laboratory reports are presented in Appendix C. A summary of the available soil characteristics data is presented in Table 3-1.

Samples of soils near the surface of the landfill indicate soils are classified as sandy clayey loams to true clays.

3.1.5 Vadose Zone Hydraulic Conductivity Measurements

Measurements of hydraulic conductivity in the vadose zone were attempted at four locations during October and November of 1992. Guelph Permeameter locations were installed at locations, G-1, G-2, and G-3 in 1992. Apparent equipment problems and seasonal temperatures prevented collection of reliable infiltration data at these three locations during November 1992. Guelph Permeameter locations were again installed at locations 93G-1, 93G-2, and 93G-3 in 1993. Guelph holes were installed by hand auguring in native soils to a total depth of 10 feet below land surface in the bottom of test pits excavated to 6 feet by backhoe. This method insured that the

strata tested was below the level of buried solid waste. Discussion and calculation of Guelph results are contained in Sections 3.1.5.2 and 3.1.5.3.

A single ring infiltrometer, R-1, was installed in October 1992 and data was collected irregularly over a period of 6 weeks. However, winter temperatures caused test water to freeze before sufficient infiltration data could be collected. In an attempt to collect reliable data, infiltration measurements at R-1 were resumed during the period from September 26 to October 1, 1993. Results of the infiltration testing are discussed in Section 3.1.5.4.

3.1.5.1 Discussion of Hydraulic Conductivity

The Guelph Permeameter (GP) provides a measure of field-saturated hydraulic conductivity (K_{fs}) and the matric flux potential (ϕ_m) of a porous medium which contains entrapped air. Field-saturated hydraulic conductivity is considered to be a more appropriate measurement than saturated hydraulic conductivity for situations where a liquid pressure head does not persist long enough for entrapped air to dissolve (Reynolds and Elrick, 1985). The GP method is a measure of total hydraulic conductivity. However, the dimensions of the test sections indicate that the conductivity in the horizontal direction is dominant. The field-saturated hydraulic conductivity values measured in typical unsaturated soils may be less than the fully saturated hydraulic conductivity by a factor of two (Stephens et al., 1987). Matric flux potential is a measurement of the soil's ability to pull water by capillary force and is dependent on the degree of saturation of the soil. The matric flux potential is zero at full saturation (Reynolds and Elrick, 1987).

The steady-state flow of water from a cylindrical well into the surrounding unsaturated soil is composed of three factors: 1) the hydraulic push provided by the hydraulic head, 2) gravitational pull, and 3) matric pull due to forces in the soils capillary fringe. The sum of the first two factors is considered to be the saturated component and is measured by K_{fs}. The third component, the unsaturated component, is measured by the matric flux, ϕ_m. The ratio of these two values, $\phi_m/K_{fs} = \alpha$, has been referred to as an absorptive length (Reynolds and Elrick, 1985) and provides a measure of the soil's ability to absorb water. The characteristic soil structure, and to some extent soil texture, have been classified according to their α values (Soilmoisture Equipment Corp, 1986). Recent studies (Elick, et al., 1989) indicate that α lies within prescribed values of 1 to 100 per meter for most field soils.

3.1.5.2 Hydraulic Conductivity Data Analysis

The Guelph Permeameter (GP) procedures consist of measuring the steady-state recharge necessary to maintain a constant depth of liquid in an uncased cylindrical well finished above the water table. Several methods of data analysis have been developed. The Richards (Reynolds and Elrick, 1985) analysis method uses strata tested was below the level of buried solid waste. Discussion and calculation of Guelph results are contained in Sections 3.1.5.2 and 3.1.5.3.

A single ring infiltrometer, R-1, was installed in October 1992 and data was collected irregularly over a period of 5 weeks. However, winter temperatures caused the water to freeze before sufficient infiltration data could be collected. In an attempt to collect reliable data, infiltration measurements at R-1 were resumed during the period from September 28 to October 1, 1993. Results of the infiltration testing are discussed in Section 3.1.5.4.

3.1.5.1 Discussion of Hydraulic Conductivity

The Guelph Permeameter (GP) provides a measure of field-saturated hydraulic conductivity (K_{fs}) and the matric flux potential (ϕ_m) of a porous medium which contains entrapped air. Field-saturated hydraulic conductivity is considered to be a more appropriate measurement than saturated hydraulic conductivity for situations where a liquid pressure head does not persist long enough for entrapped air to dissolve (Reynolds and Elrick, 1985). The GP method is a measure of total hydraulic conductivity. However, the dimensions of the test sections indicate that the conductivity in the horizontal direction is dominant. The field-saturated hydraulic conductivity values measured in typical unsaturated soils may be less than the fully saturated hydraulic conductivity by a factor of two (Stephens et al., 1987). Matric flux potential is a measurement of the soil's ability to pull water by capillary force and is dependent on the degree of saturation of the soil. The matric flux potential is zero at full saturation (Reynolds and Elrick, 1985).

The steady-state flow of water from a cylindrical well into the surrounding unsaturated soil is composed of three forces: 1) the hydraulic push provided by the hydraulic head, 2) gravitational pull, and 3) matric pull due to forces in the soils capillary fringe. The sum of the first two factors is considered to be the saturated component and is measured by K_s. The third component, the unsaturated component, is measured by the matric flux, ϕ_m. The ratio of these two values, $\phi_m/K_s = \alpha$, has been referred to as the sorptive length (Reynolds and Elrick, 1985) and provides a measure of the soils ability to absorb water. The characteristic soil structure, and to some extent soil texture, have been classified according to their α values (Soilmoisture Equipment Corp, 1986). Recent studies (Elrick, et al., 1989) indicate that α lies within prescribed values of 1 to 100 per meter for most field soils.

3.1.5.2 Hydraulic Conductivity Data Analysis

The Guelph Permeameter (GP) procedures consist of measuring the steady-state recharge necessary to maintain a constant depth of liquid in an uncased cylindrical well finished above the water table. Several methods of data analysis have been developed. The Richards (Reynolds and Elrick, 1985) analysis method uses two liquid depths in succession in a single well, while the Laplace (Reynolds and Elrick, 1985) and Gardner (Reynolds and Elrick, 1985) analysis requires only one liquid depth and provides an overestimate of K_s and ϕ_m. The Richards analysis solves simultaneous equations for K_s and ϕ_m without the use of the α parameter. The Laplace analysis assumes that α is infinitely large and provides an upper limit value for K_s. The Gardner analysis assumes that α is zero and provides a maximum value for ϕ_m. The overestimation of K_s is at a minimum for coarse and/or wet porous media and the overestimation of ϕ_m is at a minimum for fine and/or dry porous media (Reynolds and Elrick, 1985). A single head analysis has recently been developed by Reynolds and Elrick (1989) which utilizes independently determined or estimated α values.

Analysis of the GP data using the Richards Analysis Method can yield unrealistic values for K_s and ϕ_m in heterogeneous porous media (Reynolds and Elrick, 1985) and under variable temperature conditions (Soilmoisture Equipment Corp, oral communication, 1993). This anomaly can be resolved by repeating the test until realistic (i.e. positive values for both K_s and ϕ_m) data is obtained or by subjecting the data to the Laplace and Gardner analysis to obtain maximum K_s and ϕ_m values.

Because the GP is extremely sensitive to soil homogeneity, pre-existing soil moisture conditions, and temperature variations of the water in the GP reservoir, multiple tests were conducted at each location during the 1993 field tests in order to obtain sufficient reliable data to permit use of the Richards double head analysis method or replicates for a single head analysis. The soil encountered in the GP holes at the Laurel Landfill is believed to be essentially homogeneous and is classified as sandy clayey loam fine silt (clay). The soil was assumed to be near saturation conditions during the 1993 GP tests due to 1.6 inches of precipitation on September 12, just prior to the performance of the GP tests which were performed on September 15; verification testing of holes was conducted September 20 to 22, 1993. The soil type and assumed moisture conditions suggest that the reduction of field measurement data using the Laplace and Gardner analysis methods would yield results that are near minimum overestimates.

3.1.5.3 Guelph Permeameter Readings

Reportedly, during landfilling operations at the site, trenches were excavated to approximately 10 feet below the land surface for placement of waste and the waste was covered with excavated or borrowed native materials and soil (see Figure 3-2). The 1992 GP test holes were installed at total depths of less than three feet below ground surface and did not intercept the horizon expected to lie at the base of the waste. The 1993 GP wells were installed at approximately 10 feet below ground surface at locations immediately adjacent to waste trenches. Cover material may have been placed at these locations. At 93G-1, 93G-2, and 93G-3 the GP holes were installed at depths of 10.0 feet, 6.9 feet, and 9.7 feet, respectively. No buried waste

was encountered at 93G-3; this test hole is believed to be installed beyond the limit and in strata below the base of buried waste. Hole 93G-1 is located along the crest of a surface drainage divide and low ridge extending from the south onto the landfill. Due to its present elevation and surface character, this location may not have received buried waste. At 93G-2, testing was conducted below the base of buried waste at a depth of 6.9 feet due to the presence of a shallow water table (7.7 feet) at that location at that time.

Steady rates of infiltration were obtained at two head levels with one replicate at the shallow head level at each of the three 1993 GP holes. Calculations of K_s and ϕ_m were made using the single head analysis at two α values (0.12/cm and 0.025/cm), the Laplace, and Gardner analysis methods. The results are summarized in Table 3-2. Raw data and calculations are presented in Appendix D.

The Richards analysis results frequently fail to provide results considered valid in nonuniform, structured soils (Elrick, et al, 1989). Data reduction using the Richards double head analysis method yielded unrealistic negative values for ϕ_m which may have been due to the variation in water temperature over the lengthy test period required for the low permeable soils at the landfill. Consequently, these calculations and results are not included in this report.

As shown in Table 3-2, K_s and ϕ_m are slightly dependent on the magnitude of the liquid head. These values quantify the expected hydraulic conductivity at the base of the buried waste for intermittent liquid heads. The average K_s value calculated for a typical structured soil including clay and loams (α=0.12) is 1.8 x 10^{-5} cm/sec (5.9 x 10^{-7} ft/sec) and the corresponding average matric flux is 1.8 x 10^{-4} cm^2/sec (2.0 x 10^{-7} inches^2/sec) representing infiltration primarily in the horizontal direction throughout the testing. In finer less structured, more compacted soils, (α = 0.025), capillarity will be stronger and K_s is calculated to be 7.4 x 10^{-6} cm/sec (2.4 x 10^{-7} ft/sec) and ϕ_m is calculated to be 3.0 x 10^{-4} cm^2/sec (3.2 x 10^{-7} ft^2/sec).

= .051 f

= .021 ft/d

3.1.5.4 Single-Ring Infiltration Test

During the 1992 site investigations, a single-ring infiltrometer was installed at the location R-1 to a depth of seven feet below the present land surface. Water infiltration data were collected for a period of six weeks at irregular intervals during October and November, 1992 and at one to six-day intervals during late August and September of 1993. The 1992 (GeoResearch, 1992) data was collected during a period of seasonal soil wetting and cold temperatures during which the test water became frozen preventing further testing. It was assumed that steady state conditions had been reached by September 1993 and the data obtained was used to calculate field-saturated hydraulic conductivity using the constant head method of Reynolds and Elrick (1990). An essentially constant head was maintained by refilling the infiltrometer each monitoring day after the drop in the observed water level was

determined and recorded. Throughout the 1993 monitoring period, the variation in the head was less than 0.5 percent.

Calculations of soil infiltration (hydraulic conductivity) from R-1 are included in Appendix D calculations and were made for structured soils ($\alpha = 0.12$) and for less structured clay ($\alpha = 0.025$). The single ring infiltrometer calculation indicated a maximum hydraulic conductivity at $\alpha = 0.025$ of 1.7×10^{-7} cm/sec (5.6×10^{-9} ft/sec) and matric flux of 6.8×10^{-6} cm^2/sec (7.3×10^{-9} ft/sec) in the vertical direction over the month of September 1993. The depth of R-1 is similar to the Guelph wells. At its total depth (7.0 feet), R-1 was stopped in yellowish-brown, lean clay and is believed to be in the Midway-Shale Outcrop soils complex. No refuse was encountered in this wellbore. At R-1, the soils do not appear to have been reworked and the location may be at or near the limit of buried waste.

3.1.5.5 Hydraulic Conductivities

Assuming low structure clay soils, total hydraulic conductivity of 7.4×10^{-6} cm/sec (2.4×10^{-7} ft/sec) for compacted days is calculated from the Guelph Permeameter data and vertical hydraulic conductivity of 1.7×10^{-7} cm/sec (5.6×10^{-9} ft/sec) is calculated from the single ring infiltration test. Based on these two data, the horizontal component of the total conductivity is calculated to be 7.3×10^{-6} cm/sec (2.4×10^{-7} ft/sec). Thus, hydraulic conductivity is primarily in the horizontal direction which is consistent with previous studies with the Guelph Permeameter (Reynolds and Elrick, 1985).

3.2 Groundwater Investigation

During the 1992 investigation at the Laurel Landfill, four cased wells were installed to monitor the uppermost shallow groundwater at the site. One well (MW-4) was drilled in an upgradient location, three wells (MW-1, -2, and -3) were installed in downgradient locations near the south and southeast portions of the formerly active landfill. The uppermost groundwater at the landfill was encountered within the dense Niobrara formation (Colorado Shale) bedrock in all test borings. Groundwater entered the wellbores very slowly and recharge rate could not be estimated. The uppermost groundwater in MW-1 was encountered in dark brown, damp shale at approximately 17 feet below ground surface. MW-2 encountered groundwater also in dark brown shale at about 18 feet. MW-3 encountered groundwater in black shale, which underlies dark brown shale, and just below a bed of hard gray shale at approximately 36 feet below land surface. MW-4 encountered groundwater in black shale at a depth of 27 feet. Within several days following construction of wells MW-1 and MW-3, the groundwater exhibited pressure heads and rose 13 and 16 feet, respectively above the water-bearing zones. These wells are considered to be completed in a confined aquifer(s). Water levels in the other two

wells show minor rises of approximately 1 to 3 feet above the water-bearing zone and may be unconfined.

In September, 1993, monitoring well 93MW-2D was drilled to a total depth of 100 feet. The purpose of this well was to characterize the relationship between and shallow and deeper water-bearing zones at the site. MW93-2D was drilled and installed approximately 20 feet south of MW-2. Six-inch steel surface casing was driven in five foot increments to prevent potential cross contamination from the known contaminated shallow water-bearing zone in MW-2. The water-bearing zone encountered in MW-2 was not present in wellbore of 93MW-2D. Slightly damp soils were encountered in 93MW-2D from ground surface to 10 feet, from 20 to 25 feet, and at 87.5 to 90 feet. Drilling was paused for approximately one hour at depths of 17, 58, and 100 feet to allow groundwater to accumulate and be conclusively detected in the unfinished borehole. Upon removal of the well probe cable from the 100 foot depth, it was found to be wet and muddy from 75 to 100 feet. A well was constructed and screened from approximately 69 to 79 feet in dense black shale, the apparent water-bearing zone. This well is also confined and exhibits a pressure head of approximately 45 feet. The well required approximately 80 days (September 10 to November 29) to reach a static water level condition; this equates to an average recharge rate of approximately 1.1 x 10^{-4} gallons per minute or 0.1 gallons per day.

0.16gpm

Based on evaluation of 1992 drilling results, monthly water level measurements, and data obtained from the 1993 site investigations, the uppermost, shallow groundwater in monitoring wells installed at the Laurel Landfill is believed to be under both confined and unconfined conditions and originates from fractures in dense shale in bedrock. The fractures, or water bearing zones, occur at different depths and do not appear to be laterally connected between individual monitoring wells. General water quality parameters for sulfate and bicarbonate concentrations, specific conductance values, and static water levels suggest wells MW-1 and MW-3 may receive recharge from the same or an equivalent source.

Static water level measurements from all monitoring wells installed at the landfill are currently being obtained on a monthly basis for one year scheduled to end in April 1994. Water level information is currently available from November 1992 and May through December 1993.

A constant rate pumping test was conducted involving the four downgradient monitoring wells in September 1993. A slug test was also performed during the 1993 investigation in well 93MW-2D. Aquifer test data obtained during the 1992 investigations at the landfill have been re-evaluated as deemed warranted.

3.2.1 Well Completion

Details of well completion for all monitoring wells at the Laurel Landfill are presented on well completion logs in Appendix E. The Department of Health and Environmental Sciences (DHES) well completion logs are in Appendix F.

Construction of the four monitoring wells installed in 1992 consisted of two-inch diameter, flush-threaded, Schedule 40, polyvinyl chloride (PVC) casing and blank sections with a 0.020-inch slotted screen interval. The wells were screened for a height of five feet with the top of the observed water bearing zone falling within the screened interval. Silica sand, with 10/20 mesh, was used to fill the borehole annulus around the screen; a distance of approximately one foot above the top of the screen. Bentonite chips were placed above the sand. In wells MW-1 and MW-2, the chips were placed to a depth of three feet below the ground surface. In wells MW-3 and MW-4, grout consisting of Portland cement with 3 percent bentonite added was tremied into the wellbore above the chips to a depth of three feet below the ground surface. Well protection consists of six-inch diameter steel casing set to a depth of three feet, locking caps, and concrete surface seals and pads. PVC slip caps were placed on the tops of the well riser casing and matching keyed padlock were installed in the protective locking caps.

Monitoring well 93MW-2D was drilled and installed on September 10, 1993. Dry bentonite chips were gravity fed into the open borehole from 100 to 79.68 feet. The level of the chips was monitored constantly throughout installation to guard against potential bridging or the creation of voids. Two-inch diameter schedule 40 PVC tail pipe and 0.01-inch slotted screen were installed from 79.68 to 69.53 feet. Washed silica sand, 10/20 mesh, was installed in the well annulus from 79.68 to 68.00 feet. Dry bentonite chips were then poured into the well annulus from 68.0 feet to the ground surface. Bentonite chips were hydrated with potable water to form seals at depths of 35 to 42 feet and from 15 to 22 feet below ground surface. Groundwater rising in the well was allowed to hydrate the bentonite and seal the well above 68.0 feet. The PVC riser pipe is fitted with a PVC slip cap and extends from 69.53 below ground surface to 1.72 feet above ground surface inside the surface steel casing. The top of the protective steel casing (2.25 feet above ground surface) is fitted with a steel locking cap and keyed padlock.

3.2.2 Well Survey

Following well construction, wells were surveyed for relative elevations by the City of Laurel. Elevations of the top of the PVC riser casing inside the protective steel casing were based on the reported elevation of 3,585 feet above mean sea level at the northwest corner of Section 33, Township 1 South, Range 24 East as shown on the U.S. Geological Survey (USGS) topographic map for the Laurel, MT quadrangle (photo revised, 1969), as shown on Figure 2-1. Well locations for all monitoring wells

are presented on Figures 3-1 and 3-6, and the well construction logs are in Appendices E and F. Distances from the northwest corner of the section and elevations for each well are listed below:

Well Number	Distance from NE Corner of Section 33 (feet)		Top of PVC Riser Elevation (MSL)
	East	South	
MW-1	1002.7	2121.1	3533.79
MW-2	841.9	1719.1	3550.94
MW-3	493.2	2121.1	3557.49
MW-4	23.7 (west)	1228.5	3607.00
93MW-2D	841.9	1745.9	3549.40

The measuring point for all water level measurements is based on the elevation of the top of the PVC riser. The elevations determined for the monitoring wells are suitable for relative on-site use and may not be sufficiently corrected to USGS datum.

Elevations of the ground surface at each well may be determined by subtracting the measured length of the appropriate stickup above ground surface from the survey elevations.

3.2.3 Well Development

Following completion, the 1992 wells were developed using a bailer for water surging and sediment removal. The water level in MW-1 could be bailed down to a depth of approximately ten feet and development resulted in a reduction of suspended sediment in the bailed water. Other 1992 wells were easily bailed dry and development may have been relatively unsuccessful at removing all suspended sediment and filter sand from the as-built well and the producing horizon. Because wells MW-2, MW-3 and MW-4 yield less than one gpm, they are considered to be completed in water-bearing zones rather than aquifers.

Development of well 93MW-2D was performed approximately one week after construction to allow groundwater to enter the well and flush both the filter pack and screen. Development was attempted by surging and hand-bailing. However, it was quickly bailed dry and was very slow to recover. It is possible that very fine sediment may have remained in the filter sand and bottom of the well.

Well development forms are presented in Appendix F on the reverse side of the DHES monitoring well completion log.

3.2.4 Site Hydrogeology/Groundwater Flow

Levels of the static water or potentiometric surfaces for the uppermost shallow groundwater-bearing zones completed in the five monitoring wells at the Laurel Landfill have been obtained on a routine monthly basis since May 1993. In addition, one measurement is available for the initial sampling event at the landfill conducted in November 1992 (Table 3-3). These measurements are planned to continue through May 1994 to determine periods of high and low water levels at the landfill. Figure 3-5 is a hydrograph of the recorded water elevations for each well. As can be observed, there has been little significant fluctuation in the water elevations or levels at the landfill for the period monitored. In the deep monitoring well, 93MW-2D, which was installed in early September 1993, the steep rise in water level reflects the slow recharge of this confined well to static conditions.

Wells MW-1, MW-2, and MW-3 exhibit approximately equivalent static water level elevations which may indicate a common recharge area. It should be noted, however, that it is possible and considered likely that the water-bearing zones encountered in all wells drilled at the landfill including MW-4 and 93MW-2D are not continuous between wells nor representative of a single zone.

Wells MW-1 and MW-3 are considered confined due to the magnitude and elevation of the hydrologic heads observed. Also, in comparing the laboratory water quality results for sulfates, specific conductance, and bicarbonates, and the depth at which water was encountered, the wells show good agreement and appear to be commonly sourced. Well MW-2 also exhibits a water table elevation similar to the previous wells. However, it is considered unconfined because a minor head of 1.3 feet has been observed. Also, the water quality parameters reviewed for MW-2 and MW-3 are significantly different, possibly suggesting a different source of groundwater. MW-4 is an unconfined well with a much higher water elevation. Water quality indicators for this well are approximately a 50 to 70 percent less in concentration for the same parameters considered in MW-1 and in MW-2 and MW-3. Well 93MW-2D is also a confined well.

Lateral connection or equivalency of the uppermost water-bearing zones in the monitoring wells constructed at the Laurel Landfill cannot be conclusively demonstrated with the existing available drilling and aquifer test data. Lateral connection is not expected considering that the zones occur in a significantly thick, homogenous, dense, unweathered shale deposit which contains no sandy or silty horizons and fracturing is considered a plausible characterization for the occurrence and movement of groundwater. Because a common groundwater recharge or source area seems likely for wells MW-1, MW-2, and MW-3, they are mapped on Figure 3-6

as the uppermost water-bearing zone. Well MW-4 is excluded based on distance and significant water quality differences suggesting possibility of a different zone at that location. The confined well 93MW-2D is omitted in this characterization because the water-bearing zone present in MW-2 was absent at that location and the completed zone is clearly in a different and deeper zone with different confining pressures and hydrologic properties.

Based on water level measurements and calculated elevations presented in Table 3-3, the anticipated direction of groundwater movement in the uppermost shallow water-bearing zone, which is under confined and unconfined conditions at the Laurel Landfill License #203 site, is to the southeast. This flow direction is anticipated if it holds that the groundwater zone in MW-2 is connected directly, or indirectly by a common recharge area, with the confined zones in wells MW-1 and MW-3. The water-bearing zones in the latter two wells are believed to be connected. Because interconnection of the wells cannot be confirmed at this time, the gradient data are not considered to be entirely reliable. Figure 3-6 presents the possible configuration of the uppermost groundwater surface at the site as of December 29, 1993. Based on these contours, the gradient of flow is estimated to be approximately 0.0148 feet per foot (78 feet per mile).

3.2.5 Aquifer Testing

3.2.5.1 Slug Testing

Aquifer testing has been performed in all of the five monitoring wells installed at the landfill. The 1992 wells (MW-1 through MW-4) were tested after well development and initial sampling was completed. Well 93MW-2D was initially tested three days following construction and prior to sampling. Because the well had not recharged completely at the time of the first test, it was retested approximately nine weeks later.

Aquifer tests performed during the 1992 and 1993 investigations were conducted by installing a pressure transducer in the bottom of each well which was connected to an electronic datalogger to record changes in water levels at preselected time intervals throughout the test period. A solid slug was introduced into the well displacing the water level for the "slug-in" phase which was then allowed to return to its static level. The slug was then removed and the displaced water level recorded as it again returned to its static level for the "slug-out" phase of the test. This method of testing provides two data sets for some of the tested wells, 93MW-2D and MW-1. Slug-in data only was collected in MW-3; slug-out data only is available for MW-2 and MW-4.

The test in 93MW-2D was performed using a 15 psig pressure transducer and multichannel datalogger manufactured by In-Situ, Inc. The test results showed well

93MW-2D was continuing to recharge during the test period (Figure 3-5) and results could not be evaluated reliably for data analysis purposes. A second test was conducted on November 20, 1993 after the static level had been attained in the well. The slug was inserted into the well three days prior to actual testing to enable its recovery to static level. Only the slug-out water displacement levels were recorded during this test. The test was performed manually using an electronic water level probe and recording water level recovery on the basis of a digital clock.

Raw data and quantitative analysis results of the aquifer tests conducted at the Laurel Landfill are contained in Appendix D. Discussion of the quantitative results and aquifer test parameters are presented in Section 3.2.6.1.

3.2.5.2 Pump Testing

During the 1993 investigation, an extended pump test of the four downgradient monitoring wells at the landfill was conducted. An In-Situ, Inc., datalogger (model Hermit® 2000) and four pressure transducers (two-15 psig and two-20 psig) were installed in wells MW-1, MW-2, MW-3, and 93MW-2D. The objective of the test was an attempt to determine if a hydraulic connection existed between any of the water-bearing zones screened in each well. Well MW-1 was selected as the pumping well because of its location approximately midway between the other wells, its maximum downgradient position, and the head exhibited in the well. The other wells served as observation wells during the test.

Pressure trandsucers were installed below the static water level at the bottom of the cased/screened interval in each test well. To determine if any water level fluctuations were occurring in the test wells prior to initiating the pump test, water levels in the pumping well and observation wells were recorded for a period of 19 hours on September 14 and 15, 1993. A Redi-flo II electric submersible pump was then lowered to the bottom of the well approximately 22.71 feet below the top of the steel protective casing (TOSC). The pressure transducer in MW-1 was installed at a depth of 19 feet below TOSC. Water levels were monitored manually throughout the test to maintain a constant drawdown level and prevent pumping the well dry, or below the pump intake resulting in automatic shutoff and/or possible pump damage.

Immediately prior to the pump test, the displaced static water level in MW-1 was 5.75 feet below TOSC with the pump and transducer installed. Continuous pumping of well MW-1 was attempted at a discharge rate which would maintain drawdown in the well near 19 feet below TOSC (approximately 13 feet below the displaced static water level). The discharge rate of the pump was determined by timing the fill rate of a five gallon bucket and adjusted as warranted.

Following conclusion of the pump test, water levels were monitoried in all test wells for nine hours to monitor well recovery.

Raw data and graphic representation of the results for the pump test conducted at the Laurel Landfill are contained in Appendix D. Discussion of the quantitative results and aquifer test parameters are presented in Section 3.2.6.2.

3.2.6 Rate of Groundwater Movement

3.2.6.1 Slug Test Quantitative Analysis

The calculations and processed data used to determine the hydraulic properties of the water-bearing zones present at the Laurel Landfill are contained in Appendix D. Analysis of aquifer data was performed using the AQTESOLV modeling software developed by Geraghty & Miller, Inc.

The results and findings concerning the hydrogeologic conditions existing at the project site based on the 1993 studies and activities are generally consistent with those of 1992 investigation. In the previous investigation report (GeoResearch, 1992c), it was reported that the uppermost shallow groundwater bearing zone at the Laurel Landfill was located in fractured shale bedrock. Based on visual examination of a fresh exposure of shale in a cut slope near MW-4 (GeoResearch, 1992c), the fractures were described to be closely spaced and narrow. This character is described for conditions near the ground surface and likely are representative of the bedrock sediments and smectitic clays within the active zone of weathering. At depth under the weight of overburden, compressive forces should tend to close fractures. In addition, some fractures may be completely or partially sealed due to deposition of soluble minerals along fractures. Compressive closure would be greatest on horizontal fractures. Therefore, movement of groundwater would be expected to be primarily vertical through the bedrock formation.

Based on this "near-surface" appearance of the bedrock materials, the configuration and hydrologic response of the bedrock shale were assumed to be similar to materials possessing granular porosity. Therefore, standard analytical modeling techniques for evaluation of aquifer test data suited to sediments with granular porosity were used (i.e., Cooper, et. al., 1967 and Bouwer and Rice, 1976). The Bouwer and Rice method is only applicable to unconfined situations such as exist at MW-2 and MW-4. The Cooper method is applicable to confined groundwater settings in which the water-bearing zone is both homogeneous and isotropic and penetrated by a nonflowing artesian well. The method may be cautiously applied to a confined, horizontally fissured, homogeneous model (Barker and Black, 1983). However, transmissivity (T) may be over estimated by a factor of three, as consequently would be the calculated hydraulic conductivity (K) for a given thickness of "aquifer".

The thickness of the water-bearing zone or fractured interval within the screened interval of the four 1992 wells was assumed to be 1 foot. The hydrologic properties calculated for the shale bedrock water producing horizon for both confined and unconfined conditions are summarized below from the 1992 study (see also Table 3-4):

	MW1 + 3 Confined (avg.) Cooper, 1967	MW2 + 4 Unconfined (avg.) Bower & Rice (1976)	Average
T (ft^2/sec)	4.9×10^{-5}	1.74×10^{-5} (est.)	3.3×10^{-5}
K (ft/sec)	4.9×10^{-5} (est.) = 4.234 ft/da	1.74×10^{-5} = 1.50 ft/da	3.3×10^{-5} = 2.85 ft/d
Storativity (S)	0.0315	---	---

If the values are overestimated, as per Barker and Black, then T and K for the bedrock shale at the Laurel Landfill may be as low as 1.1×10^{-5}. The averaged storativity (S) value is considered high for confined aquifer conditions and may indicate the connection with unconfined conditions or possibly a surface recharge area occurring nearby.

During the 1993 investigation, a "slug-out" test was performed in well 93MW-2D for the deep water-bearing zone completed in that well. The data and analysis calculations for this well are also contained in Appendix D. Of the analysis methods used in the 1992 study, only the Cooper method is applicable to the setting in this well. The thickness of the water-bearing zone is also assumed to be 1 foot within the screened interval of the well. The values of T, K, and S calculated in 93MW-2D are 2.706×10^{-7} ft.²/sec., 2.076×10^{-7} ft./sec. (est.), and 0.00198, respectively. These results compare favorably with those from well testing performed in 1992. Conditions for movement of groundwater in bedrock in 93MW-2D should be less considering the depth below surface weathering, any resultant enhancement of flow parameters that might occur, and that fracturing should be more closed than wells nearer the surface. Based on these results, it was felt unnecessary to re-calculate the 1992 modeling information for the shale bedrock and groundwater movement at the Laurel Landfill. *

.0179 ft/da

3.2.6.2 Pumping Test Results

Throughout the pumping test, the drawdown observed and recorded in MW-1 typically ranged from approximately 18 to near 19 feet below TOSC which was approximately 12 to 13 feet below the water level at the start of the test. Continuous pumping of well MW-1 was attempted for 13 hours. Pumping actually occurred over five periods lasting 165, 70, 75, 30 and 125 minutes, totalling 7.75 hours. Pumping was interrupted when the pump quit which lasted in four periods of 45, 45, 40, and 110 minutes, respectively, totalling 4 hours. Water levels recorded by the pressure transducer indicate that at no time did the well drawdown fall below the level of the pump intake. Automatic shutoff of the pump was apparently due to overheating as

pump intake. Automatic shutoff of the pump was apparently due to overheating as the pump exhibited a slow decrease in discharge over each period of operation. The pump was able to be restarted manually at approximately the same rate following small periods of rest during which the well recharged slightly. During actual pumping, the discharge rate was maintained at approximately 0.5 gpm.

Appendix D contains both raw and processed data for the pumping well and the three observation wells. Plots of the water level data are also included for the pumping and observation wells. Well MW-2 did show a decline in water level at the start and throughout the pump test. During the test period, several purturbations were noticable which are coincident with similar events in the other wells and did occur at the same time as several minor cycles during the pump test. However, MW-2 does not respond to any of the major off cycles. Rather, it continued to decline after conclusion of the test and did not recover, or reverse, back to the pre-test level during the nine hours data was recovered after the test. The other observation wells show no effect to the pumping during the test period. On the contrary, Well 93MD-2D shows continual recharge and increasing head throughout the test and beyond. This further demonstrates that the potentiometric surface of this confined well and static conditions had not been attained.

Results of the pumping test are inconclusive concerning confirmation of communication between the water-bearing zones constructed in each of the test wells. These results may indicate that the hydraulic conductivity and transmissivity of the dense and probably fractured shale comprising the water bearing zones are significantly low or that the pump test was of insufficient duration.

3.3 Groundwater Sampling and Analysis

3.3.1 Groundwater Sampling

The list of analytes varies due to the adoption of a revised Montana Solid Waste Program (MSWP) Table 1 list of analytes. The November 1992 and May 1993 events used MSWP Table 1 which was adopted in December 1991. The September 1993 sampling event included analysis of the MSWP Table 1 parameters as revised for the October 9, 1993, rule revision and as such vary slightly from the previous MSWP Table 1 list of analytes.

Samples of groundwater were collected from each of the four monitoring wells on November 13 and 14, 1992, May 4, 1993, and September 10 and 21, 1993. Prior to sampling, the static water levels in each completed well were recorded. At each well the volume of standing water contained within the well casing was calculated based on these levels and the total depth of the well. Three standing water volumes were purged using a stainless steel bailer. In November 1992 and May 1993 prior to purging and sampling at each well, the stainless steel bailer was decontaminated

using a Liquinox and deionized (DI) water wash with a triple DI water rinse. During the September 1993 sampling, the DI water was replaced with distilled water for decontamination of equipment used to collect volatile organic samples. The DI rinse was retained for equipment used to collect the dissolved metal samples. The change in procedure occurred after GeoResearch determined that DI may contain methylene chloride and chloroform. New polypropylene rope and vinyl gloves were used at each well.

Following purging, the wells were sampled using the stainless steel bailer. Sample water was decanted into laboratory-provided 40-mL glass vials. Two drops of laboratory-provided hydrochloric acid were added to the vials and the vials were capped and stored inverted in an iced cooler. These samples were collected for analysis of Volatile Organic Compounds (VOCs). Additional sample water was then collected using the stainless steel bailer, decanted into 500 mL plastic bottles, and preserved with 2 mL of laboratory-provided sulfuric acid. These samples were collected for analysis of chemical oxygen demand (COD) and nitrogen analysis.

The wells were then sampled using a PVC bailer which was decontaminated prior to sampling using a liquinox wash, a ten percent nitric acid and DI water solution rinse, followed by a triple rinse of DI water. Sample water was decanted into a glass filtration unit which was also decontaminated with nitric acid and DI water. The water was filtered under vacuum through a filter plate with a pore size of 0.45 µm. The filtered water was transferred into a 250-mL plastic sample bottle and preserved with 2 mL of laboratory-provided nitric acid. These samples were collected for analysis of dissolved metals. Additional sample water was collected into 1 L plastic bottles using the PVC bailer and submitted for major minerals and general parameter analysis. No chemical preservatives were used in the major mineral sample.

A slightly different set of analytes was requested by the MSWP for the September 1993 sampling event. The 1 L sample was replaced by a 500 mL sample to be analyzed for general parameters and major anions. An additional sample was placed into a 500 mL plastic bottle and preserved with 2 mL of sodium hydroxide for cyanide analysis. Following the collection of laboratory samples, additional sample water was collected for determination of field parameters, pH, and specific conductivity.

All sample bottles were labeled and stored in an iced cooler as they were collected. The samples were delivered directly to Energy Laboratories in Billings under chain-of-custody. During the 1992 event, samples were labeled as "MW-1", "MW-2", etc., according to the well from which they were collected. Quality Assurance/Quality Control (QA/QC) samples included a duplicate sample collected from MW-1 which was labeled "MW-5" and an equipment blank sample which was labeled "MW-6". During the May 1993 event, samples were labeled the same as the

previous event; however, the duplicate sample, "MW-5", was collected from well MW-2, a field blank (also incorrectly called a trip blank) was labeled "MW-6", and the equipment rinse blank was labeled "MW-7". In both cases the equipment blank was collected by passing DI water through the decontaminated field equipment into sample jars and adding the same preservatives as the natural groundwater samples.

The samples collected in September 1993 were labeled using a nine character identifier. The first three characters, 993, represent the month and year of the sample collection, the second three characters represent the location, LAU for Laurel Landfill, and the final three characters are consecutive numbers from 001 through 007 representing the order in which the samples were collected. Table 3-5 provides a key to the sampling locations and sample identifiers.

3.3.2 Groundwater Sample Analyses

3.3.2.1 Field Analysis

The groundwater samples were analyzed in the field for temperature, pH, and specific conductance. The results are presented in Table 3-6 along with the corresponding laboratory analytical results.

The differences between field and laboratory reported values for pH and specific conductance are reasonable with the exception of the pH of the blank sample during the 1992 sampling event. This is likely due to lowered equipment precision in unbuffered samples such as deionized water. The reasonable agreement is an indication that sample integrity was maintained during sample delivery.

3.3.2.2 Laboratory Analysis

The 1992 and May 1993 groundwater samples were analyzed for the suite of inorganic and organic parameters contained in §16.14.706 ARM (Table 1) which had been adopted in December 1991 plus total alkalinity as calcium carbonate and tetrachloroethene (PCE). The September 1993 samples were analyzed for the parameters contained in §16.14.706 ARM (Table 1) as it was expected to be adopted in October 1993. The September list of parameters included 11 fewer inorganic parameters, eight additional dissolved metals, and the "long list" of volatile organic compounds. Five VOCs, including dichlorodifluoromethane which was previously detected at the Laurel Landfill, have been deleted and fourteen additional VOCs have been included in the "long list" which was the VOC portion of the proposed October 1993 MSWP Table 1 list. A corrected analysis to include dicholorodiflouromethane was requested in addition to the Table 1 analytes for the September 1993 samples. The laboratory reports are presented in Appendix G. Summaries of selected organic parameters are presented in Table 3-7 and summaries of selected inorganic parameters are presented in Table 3-8.

Laboratory QA/QC samples include:

- duplicate analyses for non-VOC parameters at MW-1 in 1992;
- spiked analyses for selected non-VOC parameters at MW-2 in 1992;
- water volatile surrogate recoveries for the standard spike compounds for all 1992 samples;
- matrix spike/matrix spike duplicate recovery for all 1992 samples;
- water volative surrogate recovery for all May 1993 samples;
- matrix spike/matrix spike duplicate recovery for May 1993 field blank;
- duplicate analyses for non-VOC parameters at 993LAU006 (the duplicated field sample at MW-2) in September 1993;
- method blanks for VOCs analyzed on September 20, 21, 22, and October 5, 1993;
- EPA water quality control reference sample analyzed on September 21, 1993; and
- water volatile surrogate recoveries for the standard spike compounds for all September 1993 samples.

Field QA/QC samples included:

- field duplicate at MW-1 during 1992 sampling;
- field duplicates at MW-2 during both 1993 events;
- equipment rinse blank during all events and,
- field blank during May 1993 event.

The equipment rinse blanks were analyzed for the same parameters as the groundwater samples. The field blank during the May 1993 event was analyzed for VOCs only.

3.3.2.3 Laboratory Results

All laboratory QA/QC duplicate results indicate reasonable agreement with the original sample and have been included in the results reported in Tables 3-6 through 3-8. The spiked and surrogate analyses recoveries were all within acceptable limits, and the method blanks indicated no detectable concentrations of the target analytes. These results indicate that quality control procedures in the laboratory are effective.

The results of the field duplicate samples showed close agreement and have been included in the values reported in Tables 3-6 through 3-8.

The equipment blanks collected during the 1992 and May 1993 sampling events included detectable concentrations of chloroform and methylene chloride. The equipment blank collected during the September 1993 event contained a detectable but less than quantifiable concentration of total xylenes. Between May and September 1993, GeoResearch determined that volatile organic compounds were not removed from the deionized water which was being used as a final decontamination rinse. At that time, GeoResearch modified their decontamination procedures to eliminate the DI rinse of equipment used to collect the VOC sample and thus eliminate this source of false positive VOC results. The presence of less than

quantifiable amounts of xylenes in the September 1993 equipment blank is likely due to the lingering presence of exhaust from the drill rig which was on site to drill 93MW-2D on the sampling day. The drill rig was not running at the time that the equipment blank was collected; however, it had been running several minutes earlier in the near vicinity.

The May and September 1993 equipment blanks contained very low concentrations of cadmium, iron, and/or zinc. These contaminants may be due to the use of a plated metal clip to attach the polyethylene rope to the acrylic sampling bailer. The clip was not used during the November 1992 sampling event when no metals were detected in the equipment blank. The use of this metal clip has been discontinued.

Volatile organic compounds detected in actual groundwater samples are limited to the shallow well, MW-2 (except for methylene chloride which was detected at each well in May of 1993 only and is likely due to contaminated DI rinse water). Dichlorodiflouromethane was detected in November 1992 and again in May 1993 at a slightly higher concentration. The corrected September 1993 analyses show a slight decrease in dichlorodiflouromethane concentrations. Concentrations of methylene choride have remained approximately constant (2 µg/L) at MW-2. However, it is difficult to evaluate the November and May results in light of the contamination detected in the equipment blanks for those sampling events. 1,1,1-trichloroethane was not detected until September 1993 and then in less than quantifiable concentrations in only one of the duplicate samples. Additional sampling results will be needed to confirm this result. Trichloroflouromethane was not detected in November, but was detected in May at 1.5 mg/L and again in September 1993 with a slightly higher concentration of 1.8 µg/L.

No Safe Drinking Water Act maximum contaminant level (MCL) exists for dichlorodifluoromethane or trichlorofluoromethane. The proposed and current MCLs for methylene chloride and 1,1,1-trichloroethane are 5 µg/L and 200 µg/L respectively. VOC contamination is very limited at the Laurel Landfill. Detectable concentrations which are all well below regulatory limits for drinking water have been observed in one shallow well.

Those VOCs which have been detected at the Laurel Landfill are used as: refrigerants, aerosol propellants or in the manufacture of aerosols, plastics, paint and varnish removers, degreasing agents, metal cleaning agents, pesticides, and/or blowing agents for polyurethane foam.

3.3.2.4 Groundwater Quality

Water in wells MW-1, MW-2, MW-3, and 93MW-2D is classified as Class IV and as Class III in MW-4 per the Montana Groundwater Classification System.

Overall, the quality of the groundwater in the vicinity of the site is poor. Published analytical data (Hutchinson, 1983) for a domestic well in the northwest

quarter of Section 4, approximately one mile south of the site shows exceedences of six and eight times Safe Drinking Water standards for sulfate and total dissolved solids, respectively. High levels of specific conductivity and iron were also observed in this domestic well.

The domestic well reported by Hutchinson (1983) contains lower concentrations of all constituents common to it and the Laurel Landfill wells, but the relative concentrations were similar. These waters are a sodium sulfate type which is typical of Cretaceous shales in Montana. Water in the domestic well appears to be a blend of the shale water and other water. The source of the other water could be from the alluvial aquifer which has low concentrations of total dissolved solids or from direct infiltration of meteoric water.

At the Laurel Landfill, existing or proposed maximum contaminant levels (MCLs) were exceeded at all wells including the upgradient well. The proposed MCL for sulfate, 400 or 500 mg/L, was exceeded at all wells for each sampling event. The concentration of sulfate in each well has remained relatively constant over the three sampling events. The secondary standard for manganese, 0.05 mg/L, was exceeded in each well during both the November 1992 and May 1993 events which is an additional indication of water that is not suitable for domestic use.

The current secondary standard for chlorides, 250 mg/L was exceeded at MW-3 at each sampling event and at the deep well, 93MW-2D. The chloride concentration does not appear to be increasing. Chlorides in each well appear to decrease during the spring sampling event, a time when aquifers typically are recharged with dilute meteoric water. This annual variation suggests that the chloride concentrations are due to the natural water quality, not leachate production in the landfill.

The current primary standard for nitrates, 10 mg/L, has been exceeded at MW-2 and the concentrations appear to be increasing. This high concentration may be due to the presence of cattle on the landfill site. An opening in the fence through which enough cattle move on a regular enough schedule to make a well worn path is located near MW-2. There are indications that the cattle congregate in the area of MW-2.

Table 3-9 presents the concentrations of the dissolved metals which were observed to exceed detection limits in any one of the wells during any one of the sampling events. The MCLs for arsenic, beryllium, cadmium, and silver have each been exceeded one time during the three sampling events to date. The MCL for selenium was exceeded twice in MW-2 and in MW-4, but the concentrations at both of these wells have been steadily decreasing. The iron MCL has been exceeded twice at MW-3 with decreasing concentrations and once at the deep well, 93MW-2D.

All of the wells indicated very high concentrations of total dissolved solids (TDS) and the related specific conductance. For many of the analytes evaluated, concentrations were higher at the downgradient wells than at the upgradient well. These increases could be attributable to the presence of leachate or due to a longer

residence time within the shale at the downgradient wells. MW-4 may be nearer a recharge zone for the shale water-bearing zone where the groundwater would have a shorter contact time with the shale and therefore, fewer dissolved constituents.

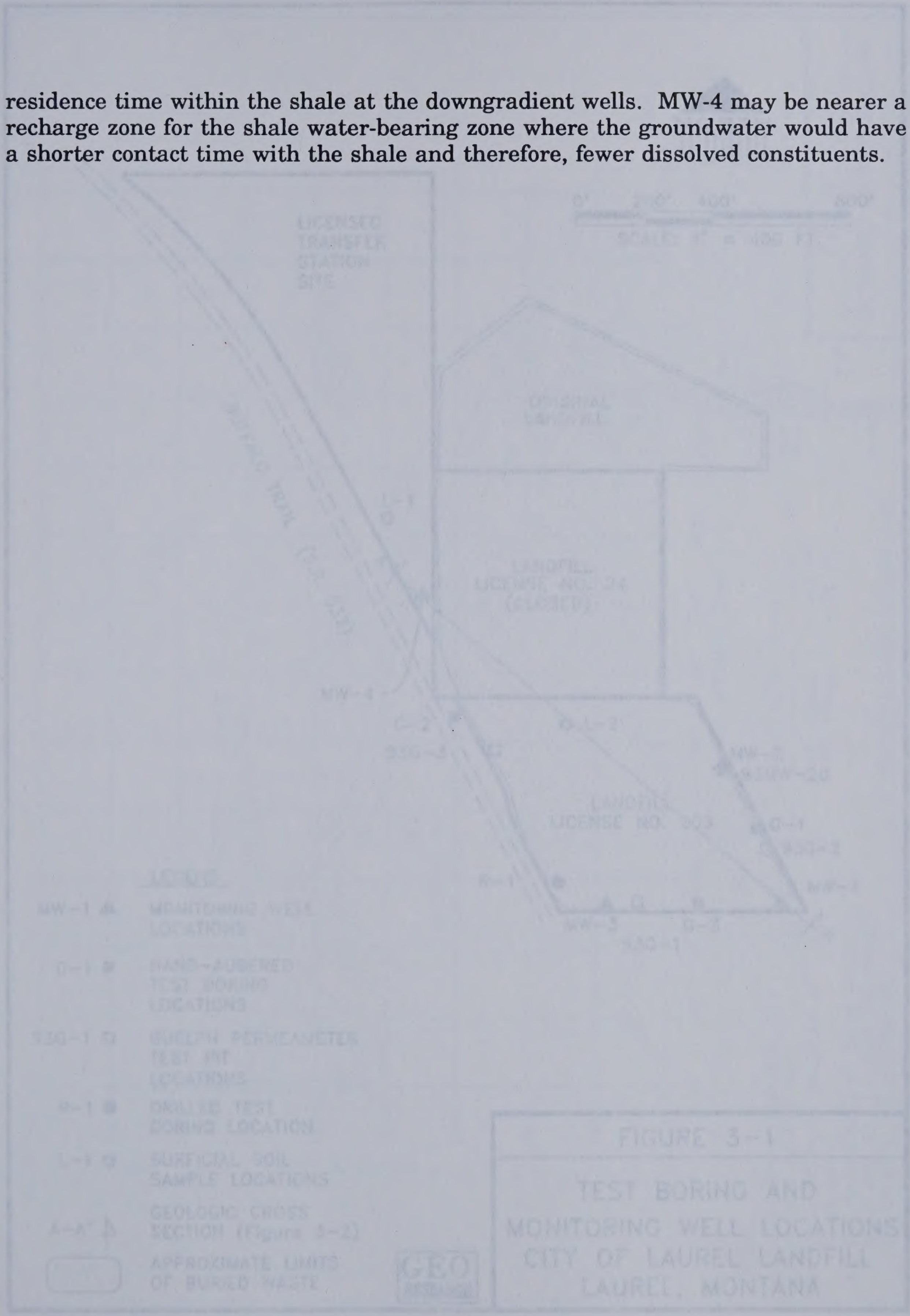

0' 200' 400' 800'
SCALE: 1" = 400 FT.
LICENSED TRANSFER STATION SITE
ORIGINAL LANDFILL
LANDFILL LICENSE NO. 24 (CLOSED)
LANDFILL LICENSE NO. 303
L-1
MW-4
G-2
SSG-3
L-2
MW-2
MW-2D
G-1
SSG-2
B-1
MW-1
MW-3
G-3
SSG-1
A
A'
LEGEND
MW-1 ▲ MONITORING WELL LOCATIONS
G-1 ■ HAND-AUGERED TEST BORING LOCATIONS
SSG-1 □ GUELPH PERMEAMETER TEST PIT LOCATIONS
B-1 ● DRILLED TEST BORING LOCATION
L-1 ○ SURFICIAL SOIL SAMPLE LOCATIONS
A-A' GEOLOGIC CROSS SECTION (Figure 3-2)
APPROXIMATE LIMITS OF BURIED WASTE
GEO

FIGURE 3-1

TEST BORING AND MONITORING WELL LOCATIONS CITY OF LAUREL LANDFILL LAUREL, MONTANA

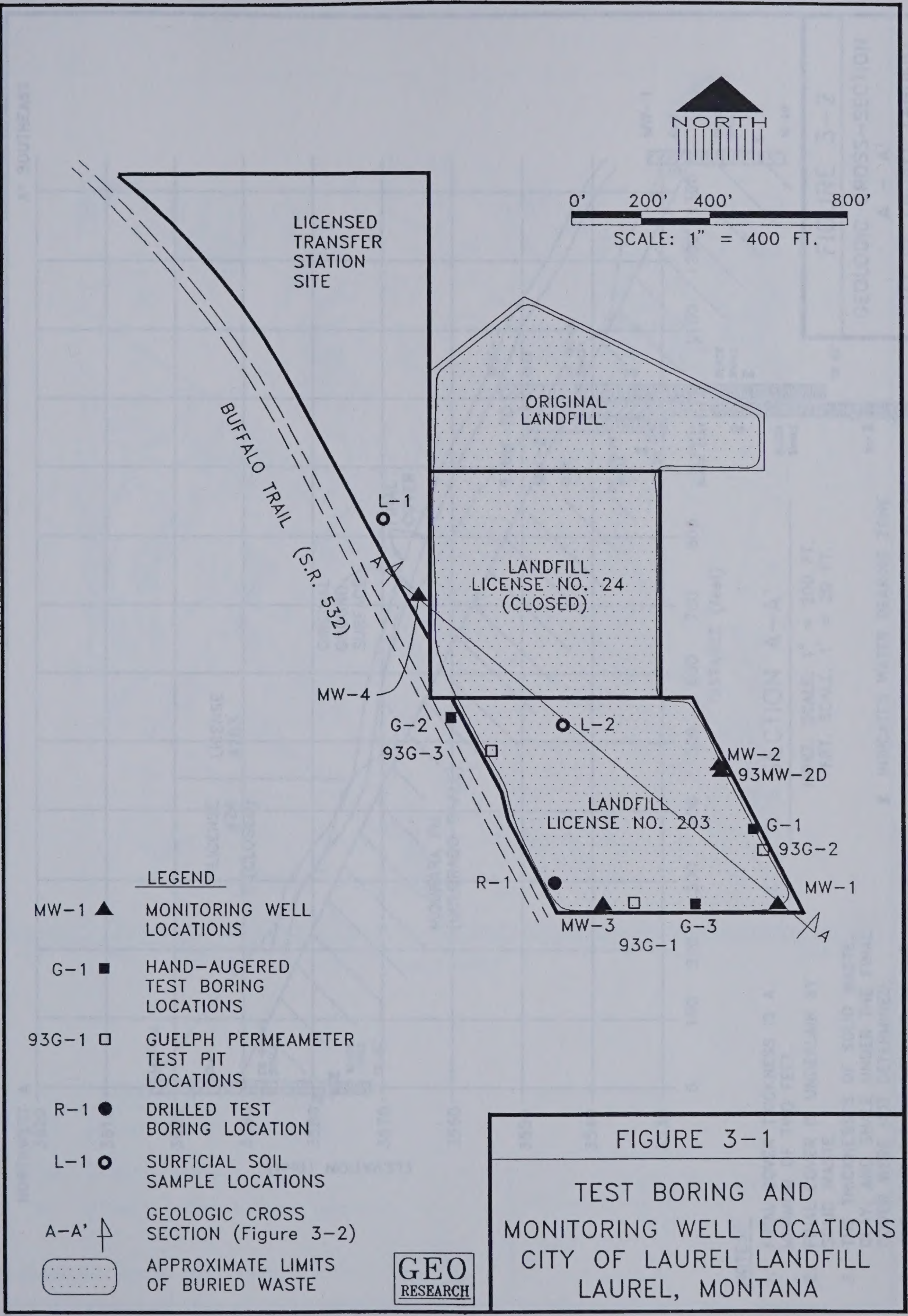
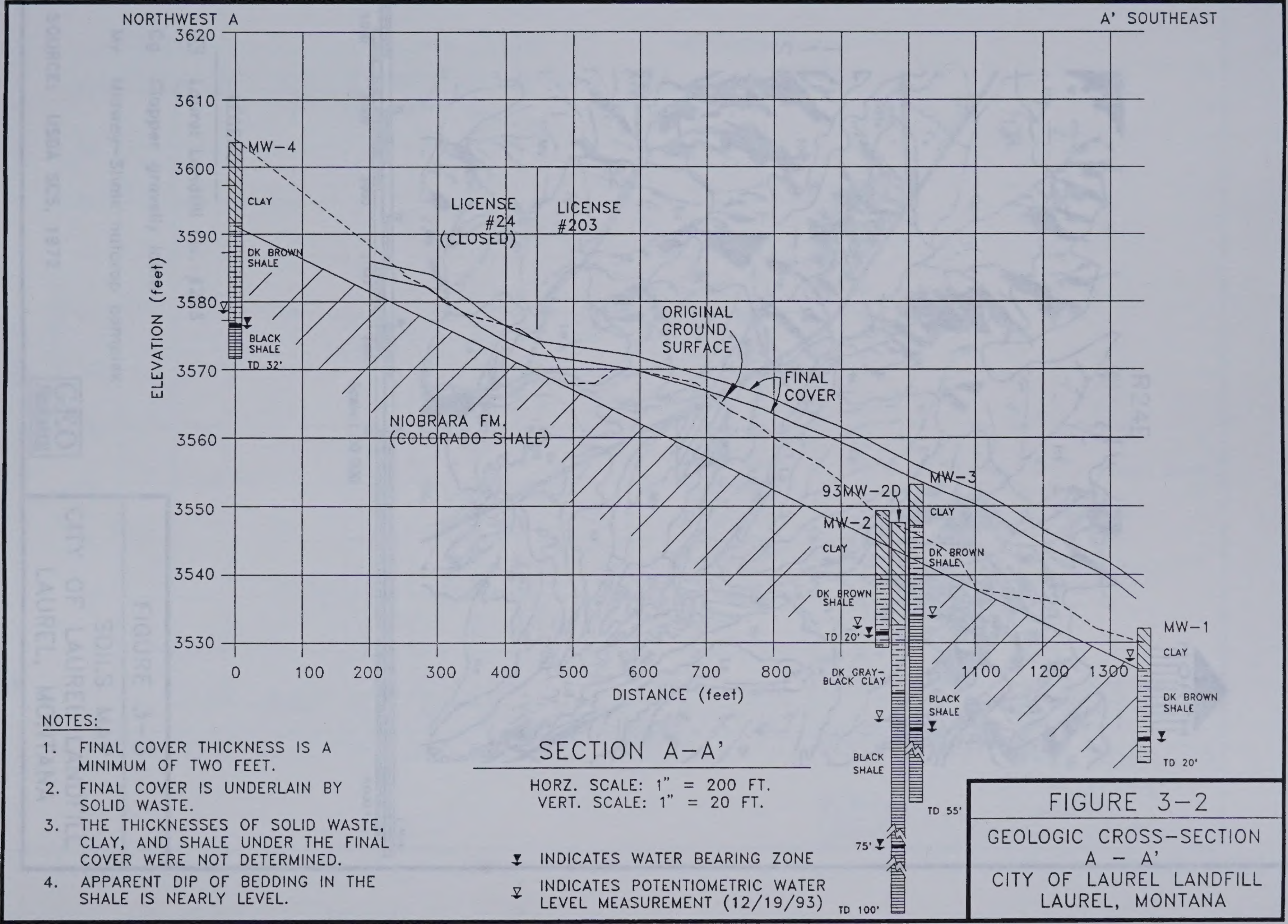

NORTH
0'
200'
400'
800'
SCALE: 1" = 400 FT.
LICENSED TRANSFER STATION SITE
ORIGINAL LANDFILL
LANDFILL LICENSE NO. 24 (CLOSED)
LANDFILL LICENSE NO. 203
BUFFALO TRAIL (S.R. 532)
L-1
A
MW-4
G-2
93G-3
L-2
MW-2
93MW-2D
G-1
93G-2
R-1
MW-1
MW-3
93G-1
G-3
A'
LEGEND
MW-1 ▲ MONITORING WELL LOCATIONS
G-1 ■ HAND-AUGERED TEST BORING LOCATIONS
93G-1 □ GUELPH PERMEAMETER TEST PIT LOCATIONS
R-1 ● DRILLED TEST BORING LOCATION
L-1 ○ SURFICIAL SOIL SAMPLE LOCATIONS
A-A' GEOLOGIC CROSS SECTION (Figure 3-2)
APPROXIMATE LIMITS OF BURIED WASTE
GEO RESEARCH

FIGURE 3-1

TEST BORING AND MONITORING WELL LOCATIONS
CITY OF LAUREL LANDFILL
LAUREL, MONTANA



NOTES:

1. FINAL COVER THICKNESS IS A MINIMUM OF TWO FEET.
2. FINAL COVER IS UNDERLAIN BY SOLID WASTE.
3. THE THICKNESSES OF SOLID WASTE, CLAY, AND SHALE UNDER THE FINAL COVER WERE NOT DETERMINED.
4. APPARENT DIP OF BEDDING IN THE SHALE IS NEARLY LEVEL.

SECTION A–A'

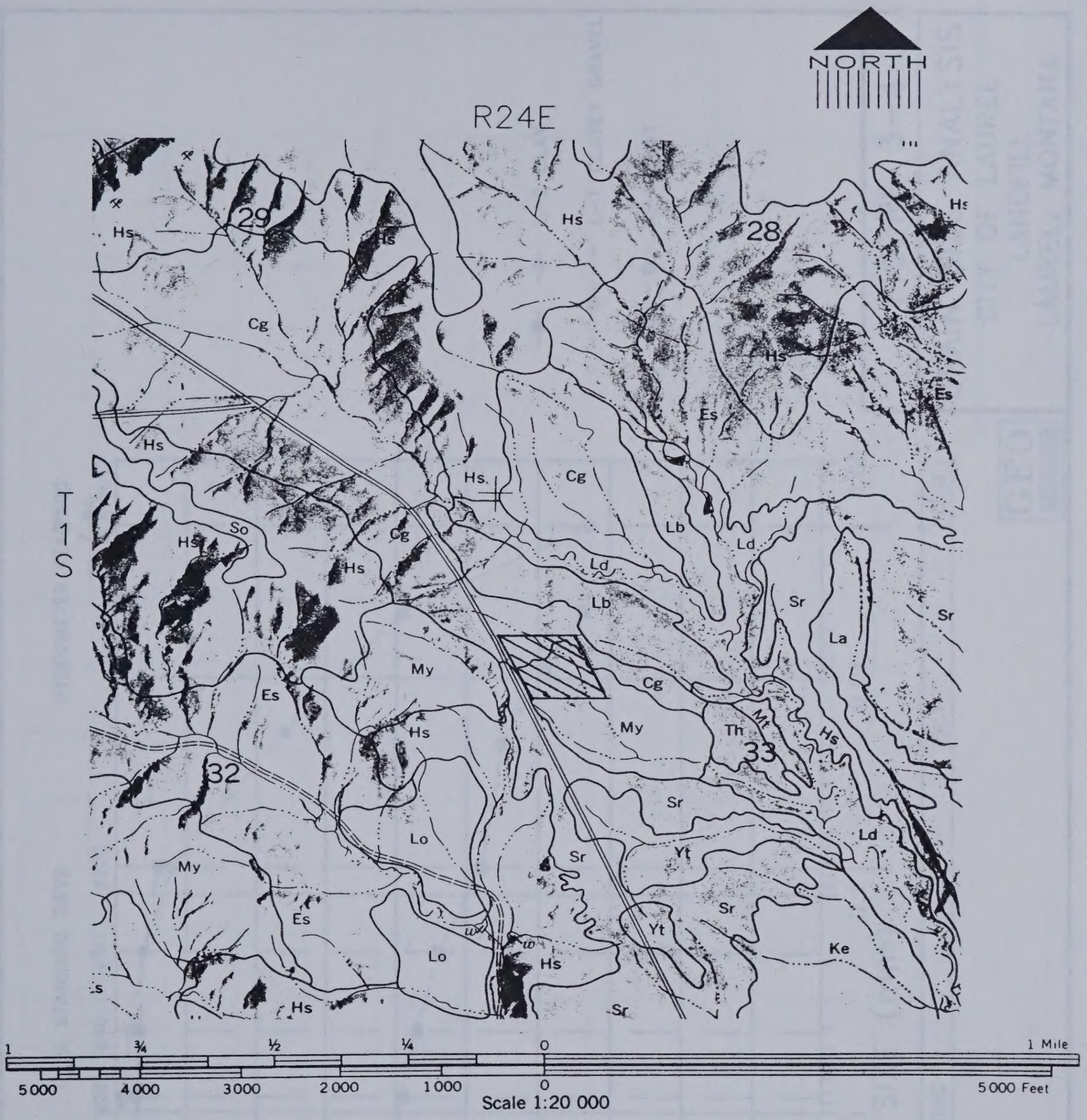
HORZ. SCALE: 1" = 200 FT.
VERT. SCALE: 1" = 20 FT.

⯆ INDICATES WATER BEARING ZONE

▽ INDICATES POTENTIOMETRIC WATER LEVEL MEASUREMENT (12/19/93)

FIGURE 3–2

GEOLOGIC CROSS–SECTION
A – A'
CITY OF LAUREL LANDFILL
LAUREL, MONTANA



LEGEND

▨ Laurel Landfill Lic. #203

Cg Clapper gravelly loam

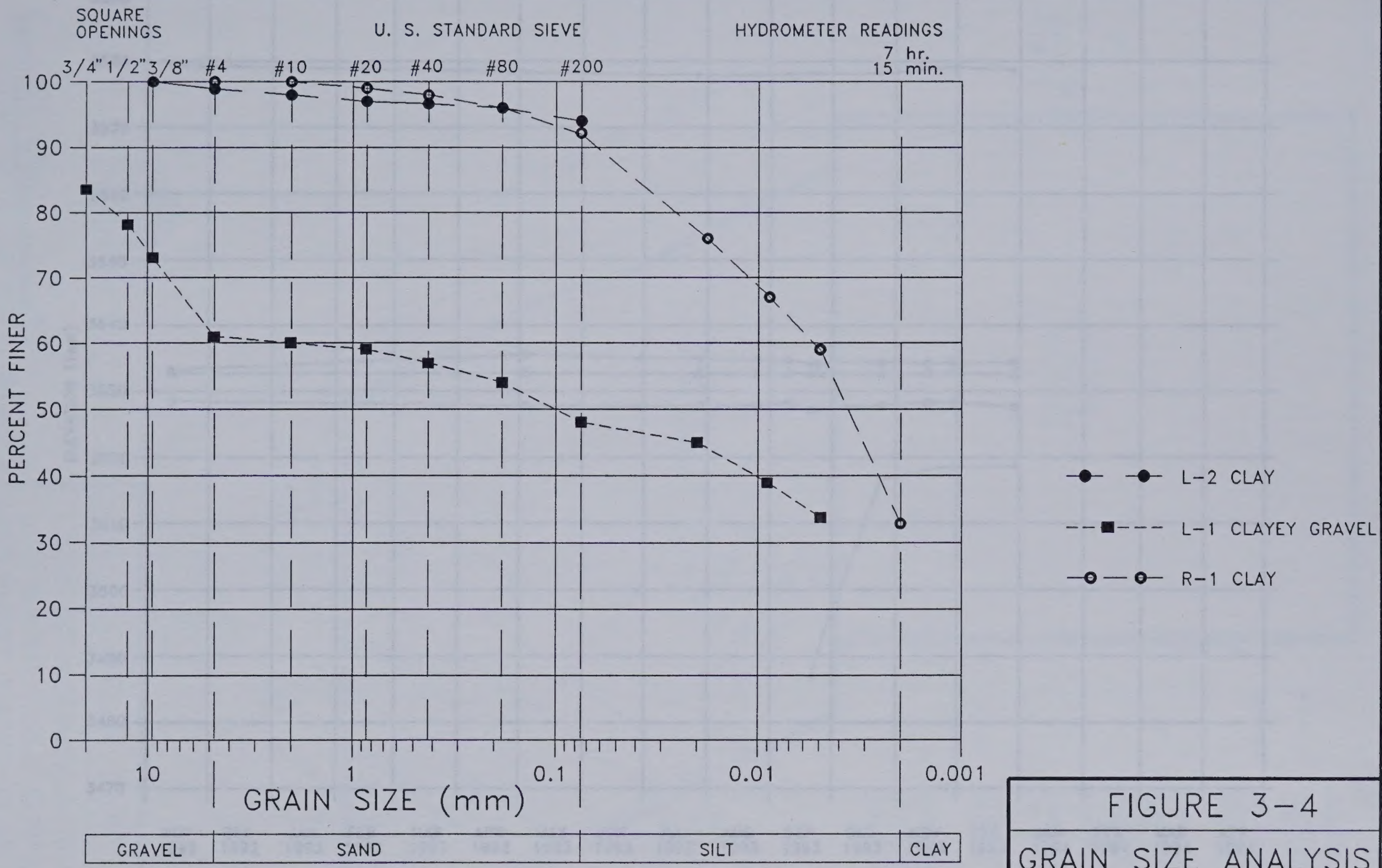
My Midway-Shale outcrop complex

SOURCE: USDA SCS, 1972

GEO RESEARCH

FIGURE 3-3

SOILS MAP
CITY OF LAUREL LANDFILL
LAUREL, MONTANA



GEO RESEARCH

FIGURE 3-4

GRAIN SIZE ANALYSIS

CITY OF LAUREL
LANDFILL
LAUREL, MONTANA

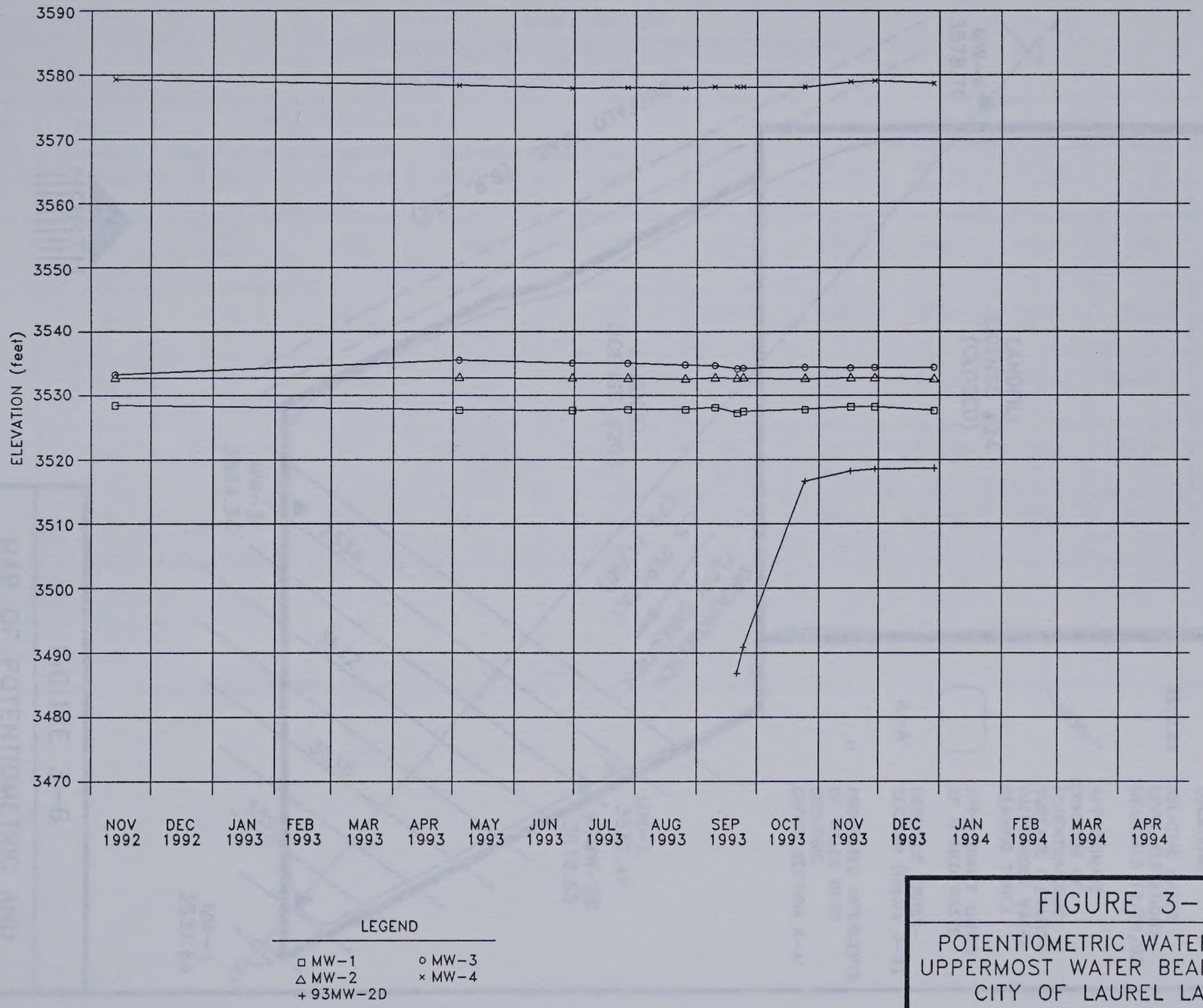


FIGURE 3−5

POTENTIOMETRIC WATER LEVELS
UPPERMOST WATER BEARING ZONE
CITY OF LAUREL LANDFILL
LAUREL, MONTANA

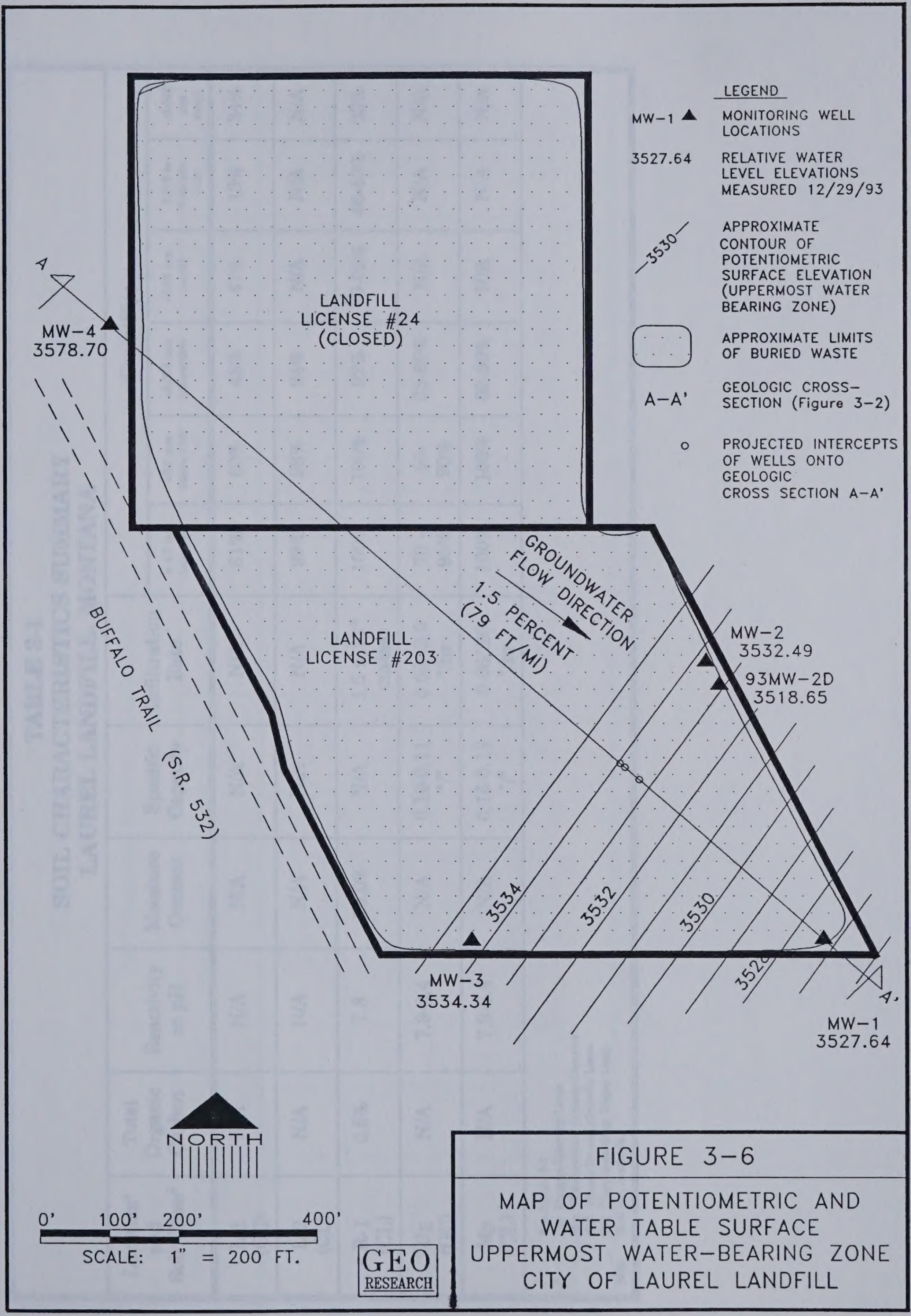

LEGEND
MW-1 ▲ MONITORING WELL LOCATIONS
3527.64 RELATIVE WATER LEVEL ELEVATIONS MEASURED 12/29/93
3530 APPROXIMATE CONTOUR OF POTENTIOMETRIC SURFACE ELEVATION (UPPERMOST WATER BEARING ZONE)
APPROXIMATE LIMITS OF BURIED WASTE
A–A' GEOLOGIC CROSS-SECTION (Figure 3-2)
o PROJECTED INTERCEPTS OF WELLS ONTO GEOLOGIC CROSS SECTION A-A'
A
MW-4
3578.70
LANDFILL
LICENSE #24
(CLOSED)
LANDFILL
LICENSE #203
BUFFALO TRAIL
(S.R. 532)
GROUNDWATER FLOW DIRECTION
1.5 PERCENT
(79 FT/MI)
MW-2
3532.49
93MW-2D
3518.65
3534
3532
3530
3528
MW-3
3534.34
MW-1
3527.64
A'
NORTH
0' 100' 200' 400'
SCALE: 1" = 200 FT.
GEO RESEARCH

FIGURE 3-6

MAP OF POTENTIOMETRIC AND
WATER TABLE SURFACE
UPPERMOST WATER-BEARING ZONE
CITY OF LAUREL LANDFILL

TABLE 3-1
SOIL CHARACTERISTICS SUMMARY
LAUREL LANDFILL, MONTANA

Location[1] and Soil Class[2]	Total Organic Carbon	Reactivity or pH	Moisture Content	Specific Capacity	Infiltration Rate	Grain Size					
						< 4.7 mm (sieve #4)	<2.0 mm (sieve #10)	<0.074 mm (sieve#200)	<0.05 mm (sand)	0.002 to 0.05 mm (silt)	<0.002 mm (clay)
L-1 (GC)	N/A	N/A	N/A	N/A	N/A	61%	60%	48%	47%	13%	34%
L-2 (CL)	N/A	N/A	N/A	N/A	N/A	99%	98%	94%	N/A	N/A	N/A
R-1 (CL)	0.5%	7.8	16.0%	N/A	1.5×10^{-6} cm/sec	100%	100%	92%	79-92%	46-59%	33%
Cg (GC)	N/A	7.9-8.4	N/A	0.10-0.11 "/'	0.63 -2.0 "/hr	70 - 95%	60- 90%	35-80%	N/A	N/A	N/A
My (CL)	N/A	7.9-8.4	N/A	0.16-0.18 "/'	0.06/.20 "/hr	100%	100%	80-90%	N/A	N/A	N/A

[1] See Figure 3-1

[2] Cg: Clapper Gravelly Loam
My: Midway-Shale Outcrop Complex
GC: Clayey Gravel, Gravelly Loam
CL: Clay, Lean Clay, Clayey Loam

N/A: data not available.

TABLE 3-2
GUELPH PERMEAMETER TEST RESULTS
LAUREL LANDFILL, MONTANA

Boring Number/ Total Depth of GP Well	Liquid Head in GP Well (cm)	Field-Saturated Hydraulic Conductivity - K_{fs} (cm/sec)			Matric Flux Potential - ϕ_m (cm^2/sec)		
		Single Head[1] (α = 0.12/cm) ft/da	Single Head[1] (α = 0.025/cm)	Laplace[2] (maximum)	Single Head[1] (α = 0.12/cm)	Single Head[1] (α = 0.025/cm)	Gardner[2] (maximum)
93G-1	5	1.2 x 10^{-6} .0034	3.7 x 10^{-7} .0010	2.9 x 10^{-6}	9.9 x 10^{-6}	1.5 x 10^{-5}	1.7 x 10^{-5}
	5	1.8 x 10^{-6} .0051	5.5 x 10^{-7} .0016	4.4 x 10^{-6}	1.5 x 10^{-5}	2.2 x 10^{-5}	2.5 x 10^{-5}
10.0 ft.	10	1.3 x 10^{-5} .0369	4.8 x 10^{-6} .0136	2.4 x 10^{-5}	1.1 x 10^{-4}	1.9 x 10^{-4}	2.4 x 10^{-4}
93G-2	5	2.7 x 10^{-5} .0765	8.3 x 10^{-6} .0235	6.6 x 10^{-5}	2.2 x 10^{-4}	3.3 x 10^{-4}	3.8 x 10^{-4}
	5	2.9 x 10^{-5} .0822	8.9 x 10^{-6} .0252	7.1 x 10^{-5}	2.4 x 10^{-4}	3.6 x 10^{-4}	4.1 x 10^{-4}
6.9 ft.	10	6.8 x 10^{-5} .1928	2.5 x 10^{-5} .0709	1.2 x 10^{-4}	5.7 x 10^{-4}	1.0 x 10^{-3}	1.3 x 10^{-3}
93G-3	5	1.7 x 10^{-6} .0048	1.1 x 10^{-5} .0312	1.9 x 10^{-5}	6.6 x 10^{-5}	4.5 x 10^{-4}	1.1 x 10^{-4}
	5	7.6 x 10^{-6} .0215	2.4 x 10^{-6} .0068	8.9 x 10^{-5}	3.0 x 10^{-4}	9.7 x 10^{-5}	5.1 x 10^{-4}
9.9 ft.	10	1.2 x 10^{-5} .0340	4.4 x 10^{-6} .0125	2.1 x 10^{-5}	9.8 x 10^{-5}	1.8 x 10^{-4}	2.2 x 10^{-4}
AVERAGE	---	1.8 x 10^{-5} .0510	7.4 x 10^{-6} .0210	4.7 x 10^{-5}	1.8 x 10^{-4}	3.0 x 10^{-4}	3.6 x 10^{-4}

[1] Reynold & Elrick (1989)

[2] Reynold & Elrick (1985)

TABLE 3-3
1993 GROUNDWATER ELEVATIONS
LAUREL LANDFILL

Parameter (feet)	Date (mm/dd/yr)	Downgradient Wells				Upgradient Well
		MW-1	**MW-2**	**93MW-2D[1]**	**MW-3**	**MW-4**
Screened Interval feet (BGS)		15 to 20	15 to 20	70 to 80	36 to 41	27 to 32
Water Level feet (BMP)	11/13/92	5.31	18.26	ND	24.23	27.71
	05/04/93	6.06	18.21	ND	22.00	28.63
	06/30/93	6.09	18.29	ND	22.46	29.11
	07/28/93	5.98	18.31	ND	22.47	29.00
	08/26/93	5.99	18.42	ND	22.74	29.08
	09/10/93	5.68	18.24	ND	22.84	28.90
	09/21/93	6.53	18.34	62.63	23.35	28.89
	09/27/93	6.25	18.29	58.52	23.25	28.75
	10/25/93	6.00	18.38	32.79	23.13	28.90
	11/17/93	5.55	18.25	31.21	23.20	28.10
	11/29/93	5.55	18.25	30.85	23.15	27.90
	12/29/63	6.15	18.45	30.75	23.15	28.30
Measuring Point Elevation feet (MSL)		3533.79	3550.94	3549.40	3557.49	3607.00
Water Elevation feet (MSL)	11/13/92	3528.48	3532.68	ND	3533.26	3579.29
	05/04/93	3527.73	3532.73	ND	3535.49	3578.37
	06/30/93	3527.70	3532.65	ND	3535.03	3577.89
	07/28/93	3527.81	3532.63	ND	3535.02	3578.00
	08/26/93	3527.80	3532.52	ND	3534.75	3577.92
	09/10/93	3528.11	3532.70	ND	3534.65	3578.10
	09/21/93	3527.26	3532.60	3486.77	3534.14	3578.11
	09/27/93	3527.54	3532.65	3490.88	3534.24	3578.25
	10/25/93	3527.79	3532.57	3516.61	3534.37	3578.10
	11/12/93	3528.24	3532.69	3518.20	3534.29	3578.90
	11/29/93	3528.24	3532.69	3518.55	3534.34	3579.10
	12/29/93	3527.64	3532.49	3518.65	3534.34	3578.70

ND: No data available.
Measuring Point: North side of PVC riser
[1] Well Installed September 10, 1993
BGS: Below Land Surface
BMP: Below Melting Point
MSL: Mean Sea Level

TABLE 3-4
SUMMARY OF AQUIFER TESTING

Well	Aquifer Type	Method of Measurement	Method of Calculation	Result: T=Transmissivity K=Hydraulic Conductivity S=Storativity
MW-1	Confined	Slug in w/Datalogger	Cooper et al.	T= 6.1 x 10^{-5} ft^2/sec. S= 0.05
MW-1	Confined	Slug out w/Datalogger	Cooper et al.	T= 1.3 x 10^{-4} ft^2/sec. S= 0.01
MW-1	Confined	Average of MW-1 measurements		T= 9.6 x 10^{-5} ft^2/sec. K= 9.6 x 10^{-5} ft/sec. (est.)
MW-2	Unconfined	Slug out w/Datalogger	Bouwer and Rice	K= 3.3 x 10^{-5} ft/sec.
MW-2	Unconfined	Slug out w/probe	Bouwer and Rice	K= 1.6 x 10^{-5} ft/sec.
MW-2	Unconfined	Average of MW-2 measurements		K= 2.5 x 10^{-5} ft/sec.
MW-3	Confined	Slug In w/Datalogger	Cooper et al.	T= 1.9 x 10^{-6} ft^2/sec. K= 1.9 x 10^{-6} ft/sec. (est.) S= 0.003
MW-4	Unconfined	Slug Out w/Datalogger	Bouwer and Rice	K= 9.7 x 10^{-6} ft/sec.
Average of all wells				K= 3.3 x 10^{-5} ft/sec.
93MW-2D	Confined	Slug Out w/ Datalogger	Cooper et al.	T= 2.706 x 10^{-7} ft^2/sec. K= 2.076 x 10^{-7} ft/sec. S= 0.00198

Note: Hydraulic conductivity estimates for confined conditions (MW-1 and MW-3) assume a saturated thickness of one foot.

TABLE 3-5
KEY TO GROUNDWATER SAMPLE LOCATIONS
LAUREL LANDFILL, SEPTEMBER 1993

Sample Location	Sample Identification		
	November 1992	May 1993	September 1993
MW-1	MW-1	MW-1	993LAU003
MW-2	MW-2	MW-2	993LAU005
93MW-2D	Not Installed	Not Installed	993LAU007
MW-3	MW-3	MW-3	993LAU002
MW-4	MW-4	MW-4	993LAU001
Duplicate	MW-5 duplicate at MW-1	MW-5 duplicate at MW-2	993LAU006 duplicate at MW-2
Equipment Blank	MW-6	MW-7	993LAU004
Field Blank	ND	MW-6	ND

ND: no data collected.

TABLE 3-6
FIELD AND LABORATORY GROUNDWATER PARAMETERS
LAUREL LANDFILL

Parameter (units)	Sample Date (mm/yr)	Downgradient Wells				Upgradient Well	Equipment Blank
		MW-1	MW-2	93MW-2D	MW-3	MW-4	
Field Ph (standard units)	11/92	6.60	6.72	ND	7.17	6.87	7.96
	05/93	6.11	6.69	ND	6.75	6.34	ND
	09/93	6.72	6.74	8.38	7.16	6.95	7.6
Laboratory Ph (standard units)	11/92	6.9	7.0	ND	7.4	7.2	5.8
	05/93	7.0	7.4	ND	7.7	7.4	4
	09/93	6.7	6.9	8.1	7.5	7.1	6
Field Specific Conductance (mhos/cm @ 25 C)	11/92	25,100	18,600	ND	30,800	8,170	10
	05/93	27,600	19,700	ND	33,200	8,250	ND
	09/93	28,000	19,700	11,300	34,500	8,820	19
Laboratory Specific Conductance (mhos/cm @ 25 C)	11/92	27,000	18,800	ND	33,800	8,210	7
	05/93	26,200	18,700	ND	32,700	8,030	38
	09/93	27,400	19,400	11,600	33,700	8,380	3
Field Temperature (C)	11/92	12.1	12.2	ND	11.7	12.0	11.6
	05/93	13.5	11.7	ND	14.1	12.1	ND
	09/93	13.4	15.8	11.6	12.9	11.0	28.9

ND: no data collected.

TABLE 3-7
SELECTED ORGANIC ANALYTICAL PARAMETERS
LAUREL LANDFILL

Constituent (µg/l)	Sample Date (mm/yr)	Downgradient Wells				Upgradient Well	Blanks	
		MW-1	MW-2	93MW-2D	MW-3	MW-4	Equipment	Field
Chloroform	11/92	<1.0[1]	<1.0	ND	<1.0	<1.0	1.7	ND
	05/93	<1.0	<1.0[1]	ND	<1.0	<1.0	2.3	3.0
	09/93	<2.0[2]	<1.0[1]	<1.0	<2.0[2]	<2.0[2]	<1.0	ND
Dichlorodifluoromethane	11/92	<1.0[1]	4.3	ND	<1.0	<1.0	<1.0	ND
	05/93	<1.0	6.5[1]	ND	<1.0	<1.0	<1.0	<1.0
	09/93	<2.0	4.9[1]	<1.0	<2.0	<2.0	<1.0	ND
Methylene Chloride (Dichloromethane)	11/92	<1.0[1]	2.0	ND	<1.0	<1.0	4.1	ND
	05/93	10	2.2[1]	ND	10	10	7.5	10
	09/93	<2.0[2]	1.9[1]	<1.0	<2.0[2]	<2.0[2]	<1.0	ND
1,1,1-Trichloroethane	11/92	<1.0[1]	<1.0	ND	<1.0	<1.0	<1.0	ND
	05/93	<1.0	<1.0[1]	ND	<1.0	<1.0	<1.0	<1.0
	09/93	<2.0[2]	<1.0[1,3]	<1.0	<2.0[2]	<2.0[2]	<1.0	ND
Trichlorofluoromethane	11/92	<1.0[1]	<1.0	ND	<1.0	<1.0	<1.0	ND
	05/93	<1.0	1.6[1]	ND	<1.0	<1.0	<1.0	<1.0
	09/93	<2.0[2]	1.8[1]	<1.0	<2.0[2]	<2.0[2]	<1.0	ND
Xylene[4]	09/93	<2.0[2]	<1.0[1]	<1.0	<2.0[2]	<2.0[2]	<1.0[3]	ND

[1] Average of two laboratory analyses.

[2] Practical quantitation limit reflects a 2X dilution; the sample was diluted due to non-target compound sample matrix interference.

[3] Present but less than the practical quantitation limit; present in only one of the duplicate samples.

[4] Xylenes were not detected in the 11/92 or the 05/93 samples.

ND: No data available.

Note: Other parameters evaluated, but not detected; see laboratory reports in Appendix G.

TABLE 3-8
SELECTED INORGANIC ANALYTICAL PARAMETERS
LAUREL LANDFILL

Constituent (mg/l)	Sample Date (mm/yr)	Downgradient Wells				Upgradient Well	Blanks	
		MW-1	MW-2	93MW-2D	MW-3	MW-4	Equipment	Field
Sulfate	11/92	25,000[1]	16,400	ND	23,900	5,530	2	ND
	05/93	25,000	16,700[2]	ND	23,400	5,560	2	ND
	09/93	24,700	17,000[1]	111	22,700	5,430	1	ND
Chloride	11/92	191[1]	199	ND	354	96	<1	ND
	05/93	189	184[2]	ND	304	73	<1	ND
	09/93	190	205	3,300	351	99	<1	ND
Chemical Oxygen Demand	11/92	40[1]	53	ND	10	20	2	ND
	05/93	38	57[2]	ND	<1	10	<1	ND
	09/93	47	56[1]	<1	10	14	<1	ND
Nitrate as N	11/92	<0.05[1]	51.5	ND	0.14	1.29	<0.05	ND
	05/93	<0.05	51.7[2]	ND	<0.05	1.73	<0.05	ND
	09/93	0.07	54.5[1]	0.19	0.46	1.70	<0.05	ND
Total Cyanide	11/92	<0.005[1]	<0.005	ND	<0.005	<0.005	<0.005	ND
	05/93	<0.005	<0.005[2]	ND	<0.005	<0.005	<0.005	ND
	09/93	<0.005	<0.005[1]	<0.005	<0.005	<0.005	<0.005	ND

[1] Average of three laboratory analyses.

[2] Average of two laboratory analyses.

ND: No data available.

Note: Other parameters evaluated in November 1992 and May 1993; see laboratory reports in Appendix G.

TABLE 3-9
SELECTED DISSOLVED METALS
LAUREL LANDFILL

Constituent (mg/l)	Sample Date (mm/yr)	Downgradient Wells				Upgradient Well	Blanks	
		MW-1	MW-2	93MW-2D	MW-3	MW-4	Equipment	Field
Arsenic	11/92	0.012[1]	<0.05[3]	ND	0.005	<0.005	<0.005	ND
	05/93	<0.005	<0.005[2]	ND	<0.005	<0.005	<0.005	ND
	09/93	0.08	<0.005[1]	0.020	<0.025[3]	<0.005	<0.005	ND
Barium	11/92	<0.1[1]	<0.1	ND	<0.1	<0.1	<0.1	ND
	05/93	<0.6[3]	<0.6[2,3]	ND	<0.1	<0.1	<0.1	ND
	09/93	<0.1	<0.1[1]	0.7	<0.1	<0.1	<0.1	ND
Beryllium	11/92	ND	ND	ND	ND	ND	ND	ND
	05/93	ND	ND	ND	ND	ND	ND	ND
	09/93	<0.001	<0.001[1]	0.003	<0.001	<0.001	<0.001	ND
Cadmium	11/92	<0.01[1,3]	0.024	ND	<0.01[3]	<0.001	<0.001	ND
	05/93	<0.006[3]	<0.006[2,3]	ND	<0.001	<0.001	<0.001	ND
	09/93	<0.001	0.004[1]	0.001	0.001	<0.001	0.001	ND
Chromium	11/92	<0.1[1,3]	<0.1[3]	ND	<0.1[3]	<0.01	<0.01	ND
	05/93	<0.06[3]	<0.06[2,3]	ND	<0.01	0.01	<0.01	ND
	09/93	0.03	0.02[1]	<0.01	<0.01	0.01	<0.01	ND

[1] Average of three laboratory analyses.
[2] Average of two laboratory analyses.
[3] Detection limit raised due to sample matrix interferences.
ND: No data available.
Note: Other parameters evaluated; see laboratory reports in Appendix G.

TABLE 3-9 (Continued)
SELECTED DISSOLVED METALS
LAUREL LANDFILL

Constituent (mg/l)	Sample Date (mm/yr)	Downgradient Wells				Upgradient Well	Blanks	
		MW-1	MW-2	93MW-2D	MW-3	MW-4	Equipment	Field
Cobalt	11/92	ND	ND	ND	ND	ND	ND	ND
	05/93	ND	ND	ND	ND	ND	ND	ND
	09/93	0.04	<0.01[1]	<0.01	<0.01	<0.01	<0.01	ND
Copper	11/92	ND	ND	ND	ND	ND	ND	ND
	05/93	ND	ND	ND	ND	ND	ND	ND
	09/93	<0.01	<0.01[1]	0.09	0.16	<0.01	<0.01	ND
Iron	11/92	<0.3[1,3]	<0.3[3]	ND	1.11	<0.3[3]	<0.03	ND
	05/93	<0.03	<0.03[2]	ND	1.02	<0.03	0.25	ND
	09/93	<0.03	<0.03[1]	2.37	0.12	<0.03	0.05	ND
Lead	11/92	<0.1[1,3]	<0.1[3]	ND	<0.1[3]	<0.1[3]	<0.01	ND
	05/93	<0.06[3]	<0.06[2,3]	ND	0.01	<0.01	<0.01	ND
	09/93	<0.01	<0.01[1]	0.04	0.03	<0.01	0.01	ND
Manganese	11/92	11[1]	0.13	ND	0.32	1.00	<0.02	ND
	05/93	10.1	<0.06[2,3]	ND	0.13	0.84	<0.01	ND
	09/93	ND	ND	ND	ND	ND	ND	ND

[1] Average of three laboratory analyses.
[2] Average of two laboratory analyses.
[3] Detection limit raised due to sample matrix interferences.
ND: No data available.
Note: Other parameters evaluated; see laboratory reports in Appendix G.

TABLE 3-9 (Continued)
SELECTED DISSOLVED METALS
LAUREL LANDFILL

Constituent (mg/l)	Sample Date (mm/yr)	Downgradient Wells				Upgradient Well	Blanks	
		MW-1	MW-2	93MW-2D	MW-3	MW-4	Equipment	Field
Nickel	11/92	ND	ND	ND	ND	ND	ND	ND
	05/93	ND	ND	ND	ND	ND	ND	ND
	09/93	0.05	0.02	0.02	<0.01	0.01	<0.01	ND
Selenium	11/92	<0.005[1]	0.89	ND	<0.005	0.18	<0.005	ND
	05/93	<0.005	0.26[2]	ND	<0.005	0.10	<0.005	ND
	09/93	<0.005	<0.005[1]	<0.005	<0.005	0.018	<0.005	ND
Silver	11/92	<0.06[1,3]	<0.06[3]	ND	0.404	<0.005	<0.005	ND
	05/93	<0.03[3]	<0.03[2,3]	ND	<0.005	<0.005	<0.005	ND
	09/93	<0.005	<0.005[1]	<0.005	<0.005	<0.005	<0.005	ND
Zinc	11/92	ND	ND	ND	ND	ND	ND	ND
	05/93	ND	ND	ND	ND	ND	ND	ND
	09/93	<0.01	<0.01[1]	1.41	0.08	0.01	0.02	ND

[1] Average of three laboratory analyses.
[2] Average of two laboratory analyses.
[3] Detection limit raised due to sample matrix interferences.
ND: No data available.
Note: Other parameters evaluated; see laboratory reports in Appendix G.

.000432 ft/da V

H

.0201 ft/da

4.0 CONCLUSIONS

Based on the evaluation of results and findings described in the previous sections for investigations conducted at the Laurel Landfill during 1992 and 1993, the following conclusions are made concerning the landfill site:

1. The shallow uppermost groundwater underlying the Laurel Landfill is classified as Class III and IV based on established criteria contained in ACM 16.12.1002. In general, these classifications are considered suitable only for some industrial and commercial purposes and not for human consumption without pretreatment.

2. The surficial soils at Landfill License #203 and those used during landfilling operations consist of the yellowish brown clay belonging principally to the Midway-Shale outcrop complex. The soils are unsaturated and display low hydraulic conductivity to a depth of 10 feet below land surface, and below buried waste, as measured by investigations conducted using a Guelph Permeameter and a single-ring infiltrometer installed in 1992; calculated conductivities are 5.6 x 10^{-9} ft/sec vertically and 2.4 x 10^{-7} ft/sec horizontally.

1993 recalc R-1 → .000432 ft/da 1993 [illegible] MW-2D .0201 ft/da

3. Surface soils are underlain by bedrock consisting of dark brown clay and shale and dense gray to black shale belonging to the Niobrara formation. The brownish sediments may represent weathered bedrock materials. The bedrock unit contains no silty or sandy horizons and is a homogeneous deposit of shale over 100 feet thick as drilled in 93MW-2D.

4. The uppermost groundwater at the landfill is present only within bedrock materials and exists under both confined and unconfined conditions. A common recharge area of the unconfined well MW-2 and confined wells MW-3 and MW-4 is indicated based on comparison of measured water levels and mapping of the potentiometric surface. Comparison of general water quality parameters and correlation of the lithologies encountered indicate the groundwater encountered at the landfill originates from fractured horizons which may not extend to other wellbores.

5. Nitrates were detected and confirmed to exist within the groundwater at the landfill. Concentrations detected are at levels in excess of "Groundwater quality standards" set forth in ACM 16.20.1003. Several VOCs have been detected only in the downgradient well MW-2 and are not present in any of the other wells, notably site background well MW-4. These concentrations do not exceed any established drinking water standards.

6. Calculations to determine the extent and rate of movement of possible contaminants at the Laurel Landfill were made using aquifer test data obtained during 1992 and 1993. Assuming generation of leachate near the center of License #203 and infiltration into the unsaturated and undisturbed bedrock at the base of the landfill, approximately 102 years would be required

for the liquids to migrate the 18 feet vertically (see Section 3.1.5.5) through unsaturated clays and shale to the surface of the uppermost water-bearing zone. Approximately 30 feet of soil and geologic sediments occur from the graded land surface (GeoResearch, 1992b) to the surface of the water-bearing zone (Figure 3-6) at the site. Movement and transport of leachate constituents in the uppermost groundwater would require approximately an additional 32 to 96 years (assuming $K = 3.3 \times 10^{-5}$ and 1.1×10^{-5} ft/sec., respectively) to extend offsite following the most direct downgradient route. The existence of constituents detected in MW-2 suggests the likelihood of a nearby source for the pollution in MW-2.

Calculations to Determine the Extent and Rate of Possible Contaminant Movement, Laurel Landfill (License #203), Montana

A. Vertical Movement (Unsaturated Sediments):

Assumptions:

1) Soil cover and cap are 2.0 feet thick. Waste disposal pits were excavated to 10.0 feet below the base of the soil cover and into native soils or weathered bedrock.
2) Distance from base of waste to the surface of the uppermost water-bearing zone is 18 feet vertically, and is unsaturated.
3) Vertical Hydraulic Conductivity: $K_{fs} = 5.6 \times 10^{-9}$ ft/sec

Calculation:

Vertical velocity = (K_{fs} ft/sec) x [sec/hr x hrs/yr]
= (5.6×10^{-9} ft/sec) x [3.15×10^{7} sec/yr]
= 0.1764 ft/yr

Years to Reach Groundwater = (18 ft / 0.1764 ft/yr) = 102 yrs

B. Horizontal Movement (Water Table/Potentiometric Surface):

Assumptions:

1) Porosity of Bedrock Shale = 10 percent.
2) MW-1, MW-2, and MW-3 are in communication via a common recharge area, but may not be connected laterally between wellbores. 93MW-2D is not connected with these wells.
3) Average hydraulic gradient from center of License #203 to southeast corner of landfill boundary is 0.18 ft/ft (1.5 %), December 1993.
4) Distance from the center of License 203 to southeast corner of landfill boundary is 600 ft.
5)

	Minimum	Maximum
Hydraulic Cond. (ft/sec)	1.1×10^{-5}	3.3×10^{-5}
Transmissivity (ft²/sec)	1.1×10^{-5}	3.3×10^{-5}

Calculation:

Horizontal velocity = [(K)(gradient)/porosity] x [sec/hr x hrs/yr]

At minimum K: = [(1.1×10^{-5} ft/sec)(0.18 ft/ft) / 10] x [3.15×10^{7} sec/yr]
= 6.237 ft/yr

At maximum K: = [(3.3×10^{-5} ft/sec)(0.18 ft/ft) / 10] x [3.15×10^{7} sec/yr)
= 18.71 ft/yr

To Edge of Landfill = 600 ft / min K = 96 yrs (32 yrs max. K)

To Reach Groundwater = 102 yrs
Total Years to Edge of Landfill = 198 yrs (134 yrs max K)

5.0 RECOMMENDATIONS

The following recommendations are made concerning regulatory requirements, warranted site investigations, and groundwater well sampling and monitoring to be conducted at the Laurel Landfill:

1. No additional monitoring wells are recommended or felt necessary to be installed at this time. The distribution and completion of existing downgradient wells, a deep water-bearing horizon well, and one upgradient well, all located on land "leased" or controlled by the licensee, and outside of areas which may have received buried waste, are adequate to establish and use as the monitoring well network for the landfill during its post-closure monitoring period.

2. No additional hydrogeologic investigations related to soils or distribution and occurrence of groundwater are warranted to determine the potential of other water-bearing zones at the landfill. Based on the suspected fractured and unpredictable nature of the sediments in which groundwater occurs, it is considered impractical to attempt extensive drilling and well installations for conclusive demonstraton of relationships and interconnection of zones.

3. Test boring R-1, the single-ring infiltrometer boring, was completed with steel casing and bentonite. The boring is believed to extend to the base of buried waste at this location and could provide a pathway for entry of surface waters into the waste pile. This wellbore should be plugged and abandoned in accordance with the appropriate parts of Montana DNR regulations ACM 36.21.670, -.677, and -.679.

4. Based on current groundwater quality information, additional sampling and analysis are recommended at the Laurel Landfill. Specifically, concentrations of MSWP Table 2 analytes plus Table 1 anions, general parameters, and iron should be examined in all wells at the next groundwater sampling event. Recommendations for appropriate future sampling and analysis activities can be made based on the results of the Table 2 analyses.

5. It is recommended that an analysis of the minimum frequency, per ARM 16.14.706(4)(a) and 16.14.708(1)(d), the minimum number of analytes, per ARM 16.14.706(8) and 16.14.708(1)(b), and the smallest subset of wells, per ARM 16.14.708(1)(c), required to sufficiently monitor groundwater quality at the Laurel Landfill be initiated.

6. It is recommended that alternative enforcement standards per ARM 16.14.708(5)(d) and the necessity of remediation activities, per ARM 16.14.708(7)(e) be evaluated for the Laurel Landfill.

6.0 LIMITATIONS

The conclusions and recommendations in this report are based on:

- 5 test borings to groundwater;
- 1 test boring for permeability testing;
- 6 hand-augured borings for permeability testing;
- 6 laboratory soil tests;
- 7 aquifer tests;
- 13 unsaturated permeability tests;
- 3 groundwater sampling and analysis events; and
- The observations of our Project Hydrogeologist.

It is possible that variations in soil and bedrock conditions between borings and test pits could exist between or beyond the points of exploration, or the groundwater conditions may change; both of which may require additional studies, consultation, and possible revisions.

This report was prepared with the generally accepted standard of practice for hydrogeology which existed in Montana for similar projects at the time the report was written. No other warranty, expressed or implied, is made.

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APPENDIX A

LOGS OF NEARBY WATER WELLS

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FORM No. 605 New 7-73

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Montana Bureau of Mines and Geology

Yellowstone

STATE OF MONTANA
Department of Natural Resources and Conservation

of 21 Beartooth SUB. D.

WELL LOG REPORT

File No. 3902-943
2S-24E-4

WHITE — DEPARTMENT
PINK — BUREAU
CANA
GOLD

017988

State law requires that this form be filed by the water well driller on any water well completed by him on and after July 1, 1973 within sixty (60) days after completion of the well.

1. WELL OWNER: Name LARRY T. RIEDE Address 320½ DURLAND DR. LAUREL, MT

2. WELL LOCATION: County YELLOWSTONE ; SE¼SW¼NW¼, Sec. 4 , Twp. 2 N [✓ S] Rg. 24 [✓ E] W

3. PROPOSED USE: ✓ Domestic ___ Stock ___ Municipal ___ Industrial ___ Lawn and Garden ___ Irrigation ___ Other (*if other, specify*) ___

4. METHOD DRILLED: ___ Cable ___ Bored ✓ Forward Rotary ___ Reverse Rotary ___ Jetted ___ Other (*if other, specify*) ___

5. WELL CONSTRUCTION:
Diameter of hole 8 inches. Depth 110 ft.
Casing: ✓ Steel ___ Plastic ___ Concrete
___ Threaded ✓ Welded ___ Other (*if other, specify*) ___

Pipe Weight:	Dia.:	From:	To:
20 lb/ft.	7 inches	1+ feet	110 feet
lb/ft.	inches	feet	feet
lb/ft.	inches	feet	feet

Was perforated pipe used? ✓ Yes ___ No
Length of pipe perforated 22 feet
Was casing left open end? ✓ Yes ___ No
Was a well screen installed? ___ Yes ___ No
Material ___ Dia. ___ inches (*stainless steel, bronze, etc.*)
Perforation type: ✓ slots ___ holes
Size 1/8 set from 88 feet to 110 feet
Size 1 set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Was a packer or seal used? ✓ Yes ___ No
If so, what material Butyl
Well type: ___ Straight screen ✓ Graveled
Was the well grouted? ✓ Yes ___ No
To what depth? 8 feet
Material used in grouting Cement
Well head completion: Pitless adapter 12" above grade ✓ Other ___
(*If other, specify*) ___
Was the well disinfected? ___ Yes ✓ No

6. WATER LEVEL:
Static water level 90 ft. below land surface
If flowing: closed-in pressure ___ psi
GPM flow ___ through ___ inch pipe
Controlled by: ___ Valve ___ Reducers ___ Other, *specify* ___

7. WELL TEST DATA: ___ Pump ✓ Bailer ___ Other
(*If other, specify*) ___
Pumping level below land surface:
95 ft. after 2 hrs. pumping 15 gpm

8. WELL LOG:

Depth (ft.) From	Depth (ft.) To	Formation
0	40	Sandy Top Soil
40	90	Sand
90	105	Gravel
105	110	Blue Shale

(*Use separate sheet if necessary*)

9. DATE STARTED: 6/29/74

10. DATE COMPLETED: 8-19-74

11. WAS WELL PLUGGED OR ABANDONED? ___ Yes ✓ No
If so, how ___

12. DRILLER'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

DIGGER Drilling 197
Driller's or Firm Name *License No.*

3143 Prairie Dr. Billings, Mt 59101
Address

8-21-74

M

023 24E 048

Form No. 603 R9/82
YELLOWSTONE

File No. ______

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion

016125

1. WELL OWNER
Name Bob Auer

2. CURRENT MAILING ADDRESS
2927 Beech Ave
Billings, Montana

3. WELL LOCATION
County Yellowstone
Township 2S N/S Range 24E E/W
NW ¼ ¼ ¼ Section 4
Lot 5 Block 1-2-3 Amend
Subdivision Groshell Sub

4. PROPOSED USE Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify ______

5. DRILLING METHOD ______ cable, ______ bored,
X forward rotary, ______ reverse rotary, ______ jetted,
______ other (specify) ______

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations ______ and/or Screen ______ Kind Size	From (feet)	To (feet)
7 7/8"	6 5/8" steel .250	0	27'	Surface Pipe		
6"	5" OD PVC 160#	27'	112'	1/8 slot	106'	112'

Was casing left open end? X Yes ______ No
Was a packer or seal used? X Yes ______ No
If so, what material Bentonite
Was the well gravel packed? ______ Yes X No
Was the well grouted? X Yes ______ No
To what depth? 27'
Material used in grouting Bentonite
Well head completion: Pitless adapter
______ Yes ______ No
Top of casing 12 in. or greater above grade
X Yes ______ No

7. WHAT IS THE TEMPERATURE OF THE WATER?
______ Degrees Fahrenheit
☐ Measured ☐ Estimated

8. WATER LEVEL
Static water level 82' feet below land surface
If flowing; closed-in pressure ______ psi
______ gpm
Controlled by: ______ valve, ______ reducers,
______ other, (specify) ______

9. WELL TEST DATA X pump ______ bailer
______ other, (specify) ______
Pumping level below land surface:
108 ft. after 2 hrs. pumping 12' gpm
______ ft. after ______ hrs. pumping ______ gpm

10. WAS WELL PLUGGED OR ABANDONED? ______ Yes X No
If yes, how? ______

11. DATE COMPLETED 9-15-83

12. WELL LOG

Depth (ft.) From	To	Formation
0'	27'	Brown clay - gravel
27'	101'	Brown sticky clay
101'	112'	gravel sand

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
9-26-83
Date
Billings Drilling
Firm Name
14023 Roundup Rd, Blgs
Address
LaVern Jewett 264#
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59620 449-3962

DEPARTMENT — BUREAU COPY

111 02S 24E 10

Yellowstone

Form No. 603 R9/82

File No. ______

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after comple 016126

1. WELL OWNER
Name Bernard Coisen

2. CURRENT MAILING ADDRESS
11st + word Aye
Red Lodge MT 59068

3. WELL LOCATION
County Yellowstone
Township 2 N/S Range 24 E/W
Tract 1/4 1/4 NW 1/4 Section 4
~~Lot~~ 1 Block
Subdivision Beartooth sub.

4. PROPOSED USE Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify ______

5. DRILLING METHOD X cable, ______ bored,
______ forward rotary, ______ reverse rotary, ______ jetted,
______ other (specify) ______

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)
6	6" - 17#	0	41½

Perforations None and/or Screen None

Kind Size	From (feet)	To (feet)

Was casing left open end? X Yes ______ No
Was a packer or seal used? ______ Yes X No
If so, what material ______
Was the well gravel packed? ______ Yes X No
Was the well grouted? ______ Yes X No
To what depth? ______
Material used in grouting ______
Well head completion: Pitless adapter
______ Yes ______ No
Top of casing 12 in. or greater above grade
X Yes ______ No

7. WHAT IS THE TEMPERATURE OF THE WATER?
50 Degrees Fahrenheit
☐ Measured ☒ Estimated

8. WATER LEVEL
Static water level 22' feet below land surface
If flowing; closed-in pressure ______ psi
______ gpm
Controlled by: ______ valve, ______ reducers,
______ other, (specify) ______

9. WELL TEST DATA ______ pump X bailer
______ other, (specify) ______
Pumping level below land surface:
26 ft. after 1/2 hrs. pumping 25 gpm
______ ft. after ______ hrs. pumping ______ gpm

10. WAS WELL PLUGGED OR ABANDONED? ______ Yes X No
If yes, how? ______

11. DATE COMPLETED 11-15-83

12. WELL LOG

Depth (ft.) From	To	Formation
0	1	Top Soil + Rock
1	6	Sand Gravel + Clay
6	23	Sandy Clay
23	33	Clay
33	35	Sandy Clay
35	38	Sand
38	41½	Sand + Gravel

RECEIVED
MAR - 5 1984
DEPT. OF NATURAL RESOURCES AND CONSERVATION BILLINGS OFFICE

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

11-19-83
Date

KAL Well Service
Firm Name

2096th Ave, Laurel MT 59044
Address

Kenneth M. Bener 435
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC

32 SOUTH EWING HELENA, MONTANA 59620 449-3962

DEPARTMENT — BUREAU COPY

111 025 24E 04 B YELLOWSTONE

orm No. 603 (Rev. 3/75)

File No. 16903-943

STATE OF MONTANA
Department of Natural Resources and Conservation

White-Department
[✓ Pink-Bureau]
Yellow-Well owner
Gold-Driller

WELL LOG REPORT

Coded

State law requires that this form be filed by the water well driller withi 0017984 *completion of the well, and Form 602, Notice of Completion of Groundwater Development be filed by the well owner within 60 days after the water has been put to beneficial use.*

WELL OWNER Name Rudy Groshelle ~~Leonard & Betty Lamb~~ Current address LAUREL MONTANA

WELL LOCATION Lot 3, Block 1-2-3 Amended Subdivision Groshelle Heights
County YELLOWSTONE, or NW ¼ ____ ¼ ____ ¼ Sec. 4, T. 2 N/S, R. 24 E-W

PROPOSED USE X domestic (includes lawn and garden); ____ stock; ____ municipal; ____ industrial; ____ irrigation; ____ other (specify) ____

METHOD DRILLED ____ cable, ____ bored, X forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify) ____

WELL CONSTRUCTION
Diameter of hole 7 7/8" in.; depth 102' ft.
Casing: ____ steel, ____ plastic, X concrete, ____ threaded, ____ welded, ____ other (specify) ____
Pipe weight: Plastic Dia. 5" From 0 To 102'
____ lb/ft ____ in. ____ ft. ____ ft.
____ lb/ft ____ in. ____ ft. ____ ft.
Was casing left open end? X Yes ____ No
Was a well screen installed? ____ Yes X No
Material ____, dia. ____ in. (stainless steel, bronze, etc.)
Was perforated pipe used? X Yes ____ No
Perforation type: X slots ____ holes
Size 1/8" set from 98 ft. to 102 ft.
Size ____ set from ____ ft. to ____ ft.
Was a packer or seal used? X Yes ____ No
If so, what material Rubber & cement
Well type: ____ Straight screen ____ Graveled
Was the well grouted: ____ Yes X No
To what depth: — ft.
Material used in grouting —
Well head completion: Pitless adapter X
12 in. above grade X, other ____
(if other, specify) ____
Was well disinfected? X Yes ____ No

WATER LEVEL
Static water level 30 ft. below land surface
If flowing: closed-in pressure ____ psi
gpm flow ____ through ____ inch pipe
Controlled by: ____ valve ____ reducers ____ other (specify) ____

7. WELL TEST DATA ____ Pump X Bailer ____ Other
(if other, specify) ____
Pumping level below land surface:
80 ft. after 1 hrs. pumping 15 gpm
____ ft. after ____ hrs. pumping ____ gpm

8. WELL LOG

Depth (ft) From	To	Formation
0	10'	SOIL
10	25'	MIXED GRAVEL · DIRT & YELLOW CLAY
25	70'	CLAY & SHALE LAMINATED
70	98'	GRAVEL & BOULDERS
98	102'	PEA GRAVEL & SAND

(use separate sheet if necessary)

9. DATE STARTED July 15 - 1975
DATE COMPLETED July 16 - 1975

10. WAS WELL PLUGGED OR ABANDONED? ____ Yes X No
If so, how? /

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Roy R. Peil 170
Driller's or firm name License No.

Billings Mont.
Address

Roy R. Peil 8/15/75
Signed by date

File No. 111 028 24E 04 Bc

TRIPLICATE Yellowstone

VED
NOV 15 1968
Montana Bureau of
[illegible]ogy

T2 SouthR24 East 4

County Yellowstone

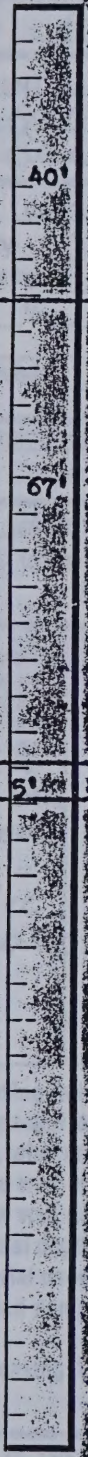
STATE OF MONTANA
ADMINISTRATOR OF GROUNDWA
OFFICE OF STATE ENGINE

017987

Notice of Completion of Groundwater Appropriation by Means of Well

(Under Chapter 237, Montana Session Laws, 1961)

Top of Ground
(Elev. above sea level 3385)



40' Dirt & Gravel

67' Yellow Clay

5' Sand & Gravel
112.5'

Show exact depth of bottom.

Owner Beartooth Enterprises Address Inc. Box 18, Laurel, Mont.

Driller Beartooth Enterprises Address Inc. Box 18, Laurel, Mont.

Date of Notice of Appropriation of Groundwater

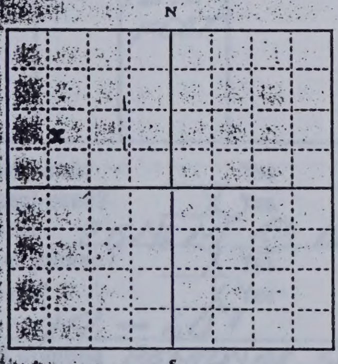
Date well started 9-4-68 Date Completed 10-11-68

Type of well Drilled (dug, driven, bored or drilled) Equipment Used Drill (Churn, drill, rotary or other)

Water Use: Domestic ☒ Municipal ☐ Other ☐ Irrigation ☐ Industrial ☐ Drainage ☐ Stock ☐

☞ Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS		
				Kind Size	From (Feet)	To (Feet)
6"	6" 19 lb. .280	0	112.5	None		



SW ¼ NW Sec. 4 T 2S R 24E

Indicate location of well and place of use, if possible. Each small square represents 10 acres.

Static Water Level for non-flowing Well 20.5 feet.

Shut-in Pressure for Flowing Well

Pumping Water Level 92 feet at 10 gal. per minute.

Discharge in gal. per min. of flowing well

How Tested Bailer Length of Test 1 hour

Remarks: (Gravel packing, cementing, packers, type of shutoff, location of place of use of groundwater if not at well, and any other similar pertinent information, including number of acres irrigated, if used for irrigation) None used.

Robert P. Rosselot
Driller's License Number

Beartooth Enterprises, Inc.
Driller's Signature

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located.

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

Original to the County Clerk and Recorder; duplicate to the State Engineer; Triplicate to the Montana Bureau of Mines and Geology and Quadruplicate for the Appropriator.

Billings   111 1S 24E 33D   Yellowstone

Form No. 603 (R 6-84)

File No. 057728

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name FRANK FELKE

2. CURRENT MAILING ADDRESS
4417 HARVEST LANE
BILLINGS, MT 59106

3. WELL LOCATION
County YELLOWSTONE
Township 1 N/[✓ S] Range 24 [✓ E]/W
¼ E½SE¼ Section 33
Lot ______ Block ______
Subdivision LAUREL AIRPORT

4. PROPOSED USE Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify ______

5. DRILLING METHOD ______ cable, ______ bored,
X forward rotary, ______ reverse rotary, ______ jetted,
______ other (specify) ______

6. WELL CONSTRUCTION AND COMPLETION

Perforations 1/4 INCH and/or Screen ______

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Kind Size	From (feet)	To (feet)
7 7/8"	6 5/8" 1/4 WALL STEEL	0'	15'			
7 7/8"	6" PVC 160PSI	15'	98'	1/4" HOLES, 12 PER FOOT	60'	98'

Was casing left open end? ______ Yes X No
Was a packer or seal used? X Yes ______ No
If so, what material CEMENT @ 15'-SURFACE
Was the well gravel packed? X Yes ______ No
Was the well grouted? X Yes ______ No
To what depth? 15' – 60'
Material used in grouting BENTONITE SLURRY
Well head completion: Pitless adapter
X Yes ______ No
Top of casing 12 in. or greater above grade
X Yes ______ No

7. WHAT IS THE TEMPERATURE OF THE WATER?
45° Degrees Fahrenheit
☐ Measured ☒ Estimated

8. WATER LEVEL
Static water level 48' feet below land surface
If flowing; closed-in pressure ______ psi
______ gpm
Controlled by: ______ valve, ______ reducers,
______ other, (specify) ______

9. WELL TEST DATA ______ pump ______ bailer
______ other, (specify) AIR PUMP
Pumping water level below land surface:
60 ft. after 1 hrs. pumping 40 gpm
60 ft. after 2½ hrs. pumping 40 gpm

10. WAS WELL PLUGGED OR ABANDONED? ______ Yes X No
If yes, how? ______

11. DATE COMPLETED ______

12. WELL LOG

Depth (ft.) From	To	Formation
0'	30'	SOIL, SHALE GRAVEL
30'	90'	ALTERNATING SHALE AND GRAVEL, VERY LITTLE SAND

RECEIVED
SEP 25 1986
DEPT. OF NATURAL RESOURCES AND CONSERVATION
BILLINGS OFFICE

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
9-1-86
Date
SWEETWATER DRLG & EXPLORATION
Firm Name
BOX 123, BILLINGS, MT 59103
Address
Signature 468 License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59620 444-6610

State Publishing Co., Helena, Mont.

DEPARTMENT - BUREAU COPY

111 1S 24E 34 CB Yellowstone

Form No. 603 (R 6-84)

File No.

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion. 015734

1. WELL OWNER
Name MIKE VISSER

2. CURRENT MAILING ADDRESS
MR MIKE VISSER
RAPELJE, MT 59067

3. WELL LOCATION
County YELLOWSTONE
Township 1 N/S [✓ S] Range 24 [✓ E] / W
___ ¼ ~~24~~ ~~SE~~ ¼ Section ~~33~~ 34
Lot NW SW Block
Subdivision ADJACENT TO VISSER HANGER

4. PROPOSED USE Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify CROP DUSTING SUPPLY

5. DRILLING METHOD ___ cable, ___ bored,
X forward rotary, ___ reverse rotary, ___ jetted,
___ other (specify)

6. WELL CONSTRUCTION AND COMPLETION

Perforations 1/8 INCH and/or Screen

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Kind Size	From (feet)	To (feet)
8¾"	6⅝" ¼ WALL STEEL	0'	15'	1/8" 12 PER FOOT	76'	110'
8¾"	6⅝" 160 PSI PVC	15'	110'			

Was casing left open end? ___ Yes X No
Was a packer or seal used? X Yes ___ No
If so, what material CEMENT @ 15'
Was the well gravel packed? X Yes ___ No
Was the well grouted? X Yes ___ No
To what depth? 15'
Material used in grouting BENTONITE SLURRY
Well head completion: Pitless adapter X Yes ___ No
Top of casing 12 in. or greater above grade X Yes ___ No

7. WHAT IS THE TEMPERATURE OF THE WATER?
45° Degrees Fahrenheit
☐ Measured ☒ Estimated

8. WATER LEVEL
Static water level 70' feet below land surface
If flowing; closed-in pressure ___ psi
___ gpm
Controlled by: ___ valve, ___ reducers,
___ other, (specify)

9. WELL TEST DATA ___ pump ___ bailer
___ other, (specify) AIR PUMP
Pumping water level below land surface:
80 ft. after 2 hrs. pumping 35 gpm
80 ft. after 4 hrs. pumping 35 gpm

10. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If yes, how?

11. DATE COMPLETED

12. WELL LOG

Depth (ft.) From	To	Formation
0'	30'	SOIL, SHALE, GRAVEL
30'	70'	SHALE, CLAY
70'	110'	SAND, GRAVEL, CLAY

RECEIVED
MAR 18 1986
DEPT. OF NATURAL RESOURCES AND CONSERVATION BILLINGS OFFICE

HD

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Date 3/18/86

Firm Name SWEETWATER DRLG. & EXPLORATION INC.
Address P.O. BOX 123 BILLINGS, MT
Signature Ted H. Williams License No. 468

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59620 444-6610

STATE PUBLISHING CO., HELENA, MONT.

Billings 111 1S 24E 34 CDD Yellowstone

Form No. 603 (R 6-87)

File No. ____________

022263

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name Harvey E ~~AND~~ Melody E Fox

2. CURRENT MAILING ADDRESS
8325 Airport Rd.
Laurel, Mt. 59044

3. WELL LOCATION
County Yellowstone
Township 1 N/[✓ S] Range 24 [✓ E]/W
SE ¼ SE SW ¼ Section 34
Lot ____________ Block
Subdivision ____________
Tract Number ____________

4. PROPOSED USE Domestic ☐ Stock ☑ Irrigation ☐
Other ☐ specify ____________

5. DRILLING METHOD ✓ cable, ____ air rotary, ____ forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify) ____________

6.

Depth (ft.) From	To	Formation
0	5	Gravel + SAND
5	45	SAND with som Brn Clays
45	67	Clay With sand Stringers
67	74	SAND Med fine (Water Bearing)
74	82	SAND + Gravel

ATTACH ADDITIONAL SHEETS IF NECESSARY

7. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and PSI Rating of casing	From (feet)	To (feet)
6"	6"	42	82
	inserted Liner 4½" PVC	20	82

Perforations ~~None~~ and/or
Screen None

Kind Size	From (feet)	To (feet)
10 ft factory sloted casing from 72 ft to 82 ft		

Was casing left open end? ✓ Yes ____ No
Was a packer or seal used? ____ Yes ✓ No
If so, what material ____________
Was the well gravel packed? ____ Yes ✓ No
To what depth was the well grouted? 82 ft
Material used in grouting Bentonite
Pitless adapter ____ Yes ✓ ____ No
Top casing 18 in. or greater above grade ✓ Yes ____ No

8. WELL TEST DATA

The pump test information request in this section is required for all wells. All depth measurements shall be from the top of the well casing unless otherwise specified.

All wells under 100 gpm must be tested for a minimum of one hour and provide the following information:

a) Air ____ Pump ✓ Bailer ____
b) Static water level immediately before testing 40 ft. If flowing; closed-in pressure ____ psi ____ gpm
Controlled by: ____ valve, ____ reducers, ____ other, (specify) ____________
c) Depth at which pump is set for test 78
d) The pumping rate and means of discharge (i.e., bailing, airlift, pumping) 50 gpm
e) Maximum drawdown during the test 50 ft
f) Duration of test: Pumping time 3 hrs
Recovery time 2 hrs
g) Recovery water level 40 ft
Amount of time after pumping recovery level water data was taken 12 hrs

Wells intended to yield 100 gpm or more shall be tested for a period of 8 hours or more. The test shall follow the development of the well, and shall be conducted continuously at a constant discharge at least as great as the intended appropriation. In addition to the above information, water level data shall be collected and recorded on the Department's "Aquifer Test Data" form included in each packet of well logs.

NOTE: All wells shall be equipped with an access port ½ inch minimum or a pressure gauge that will indicate the shut-in pressure of a flowing well. Removable caps are acceptable as access ports.

9. WAS WELL PLUGGED OR ABANDONED? ____ Yes ✓ No
If yes, how? ____________

10. DATE COMPLETED 11-12-87

11. DRILLER/CONTRACTOR'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

11-18-87
Date

KNL Well Service
Firm Name

209 6th Ave. Laurel, MT. 59044
Address

Kenneth M. Bauer
Signature

435
License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION
1520 EAST SIXTH AVENUE HELENA, MONTANA 59620-2301 444-6610

DNRC

Billings. 111 2S 24E 03 A Yellowstone

Form No. 603 (R 2-89)

WELL LOG REPORT

File No 079519

State law requires that the Bureau's copy be filed by the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name KENNETH BEVEN

2. CURRENT MAILING ADDRESS
1730 Pinyon Dr.
LAUREL, MT. 59044

3. WELL LOCATION
____ ¼ N ½ NE ¼ Section 3
Township 2 N [✓ S] Range 24 [✓ E] W County Yellowstone
Govn't Lot ____, or Lot 8, Block 1
Subdivision Name Collingwood
Tract Number ____

4. PROPOSED USE: Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify ____

5. TYPE OF WORK:
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

6. DIMENSIONS: Diameter of Hole
Dia. 6 in. from 0 ft. to 34 ft.
Dia. ____ in. from ____ ft. to ____ ft.
Dia. ____ in. from ____ ft. to ____ ft.

7. CONSTRUCTION DETAILS:
Casing; Steel Dia. 6 from + 2 ft. to 34 ft.
Threaded ☐ Welded ☒ Dia. ____ from ____ ft. to ____ ft.
Type ____ Wall Thickness ____
Casing; Plastic Dia. ____ from ____ ft. to ____ ft.
Weight ____ Dia. ____ from ____ ft. to ____ ft.
PERFORATIONS: Yes ☐ No ☒
Type of perforator used ____
Size of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
SCREENS: Yes ☐ No ☒
Manufacturer's Name ____
Type ____ Model No. ____
Dia. ____ Slot size ____ from ____ ft. to ____ ft.
Dia. ____ Slot size ____ from ____ ft. to ____ ft.
GRAVEL PACKED: Yes ☐ No ☒ Size of gravel ____
Gravel placed from ____ ft. to ____ ft.
GROUTED: To what depth? Continuous 34 ft.
Material used in grouting Bentonite

8. WELL HEAD COMPLETION:
Pitless Adapter ☒ Yes ☐ No

9. PUMP (if installed)
Manufacturer's name ____
Type ____ Model No. ____ HP. ____

10. WELL TEST DATA

The information requested in this section is required for all wells. All depth measurements shall be from the top of the well casing. 1/-

All wells under 100 gpm must be tested for a minimum of one hour and provide the following information:

a) Air ____ Pump ✓ Bailer ____
b) Static water level immediately before testing 24 ft. If flowing; closed-in pressure ____ psi. ____ gpm.
Flow controlled by: ____ valve, ____ reducers, ____ other, (specify) ____
c) Depth at which pump is set for test 33 ft
d) The pumping rate: 24 gpm.
e) Pumping water level 32 ft. at 3 hrs. after pumping began.
f) Duration of test: Pumping time 3 hrs.
g) Recovery time 1 hrs.
h) Recovery water level 26 ft. at 1 hrs. after pumping stopped.

Wells intended to yield 100 gpm or more shall be tested for a period of 8 hours or more. The test shall follow the development of the well, and shall be conducted continuously at a constant discharge at least as great as the intended appropriation. In addition to the above information, water level data shall be collected and recorded on the Department's "Aquifer Test Data" form.

NOTE: All wells shall be equipped with an access port ½ inch minimum or a pressure gauge that will indicate the shut-in pressure of a flowing well. Removable caps are acceptable as access ports.

11. WAS WELL PLUGGED OR ABANDONED? ____ Yes ✓ No
If yes, how? ____

12. WELL LOG

Depth (ft.) From	To	Formation
0	1	top soil.
1	11	Clay
11	14	Sandy Clay + fine Gravel
14	19	Sand + fine Gravel
19	29	Sand
29	34	Sand + Gravel
		Drainage = HD

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NOV 26 1990
DEPT. OF NATURAL RESOURCES AND CONSERVATION
BILLINGS OFFICE

15-90

ATTACH ADDITIONAL SHEETS IF NECESSARY

13. DATE COMPLETED 9-29-90

14. DRILLER/CONTRACTOR'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Date 11-17-90
Firm Name KAL Well Service
Address 1730 Pinyon Dr. Lrel Mt.
Signature Kenneth M. Buen
License No. 435

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION
1520 EAST SIXTH AVENUE HELENA, MONTANA 59620-2301 444-6610
DNRC

Mi121855

02S 23 24E 03A

Form No. 603 R10/79
Yellowstone

File No.

WELL LOG REPORT

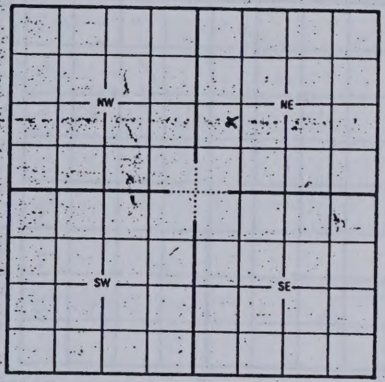
State law requires that this form be filed by the water well driller within 60 days after compl

016107

1. WELL OWNER
Name Kenneth M. Beven

2. CURRENT MAILING ADDRESS
209 6th ave
Laurel Montana

3. WELL LOCATION



¼ N ½ NE ¼ Section 3
Township 2 N [✓ S] Range 24 [✓ E] W
County Yellowstone
Lot 8 Block 1
Subdivision Collingwood
Well Elevation
Accuracy: ± 10'; ± 50'; ± 100';

4. DRILLING METHOD ✓ cable, bored, forward rotary, reverse rotary, jetted, other (specify)

5. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations and/or Screen Kind Size	From (feet)	To (feet)
6"	6" 250 Steel	0	25			

Was casing left open end? ✓ Yes No
Was a packer or seal used? Yes ✓ No
If so, what material
Was the well gravel packed? Yes ✓ No
Was the well grouted? Yes ✓ No
To what depth?
Material used in grouting
Well head completion: Pitless adapter
12 in. above grade ✓, other
(If other, specify)
Pump horsepower , pump type
Pump intake level feet below land surface
Power (electric, diesel, etc.)

6. WATER LEVEL
Static water level 12 feet below land surface
If flowing, closed-in pressure psi
gpm flow through inch pipe
Controlled by: valve, reducers, other
(if other, specify)

7. WELL TEST DATA pump ✓ bailer other
(If other, specify)
Pumping level below land surface:
ft. after hrs. pumping gpm
ft. after hrs. pumping gpm

8. WAS WELL PLUGGED OR ABANDONED? Yes ✓ No
If yes, how?

9. DATE STARTED
DATE COMPLETED

10. WELL LOG

Depth (ft.) From	To	Formation
0	4	top soil
4	10	Gravel & Rock
10	25	Gravel & Sand

HD

(use separate sheet if necessary)

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

1-28-81
Date

Beven Drilling
Firm Name

McLeod Montana 59062
Address

Thomas D Beven 294
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59601 449-3634

41.44001

Form No. 603 R10/79 02S 24E 03A
S

File No.

WELL LOG REPORT

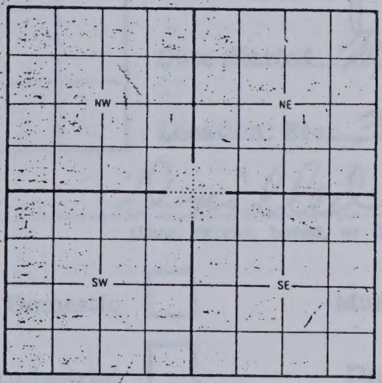
State law requires that this form be filed by the water well driller within 60 days after comp

016106

1. WELL OWNER
Name John adams

2. CURRENT MAILING ADDRESS
609 Birch ave
Laurel Montana

3. WELL LOCATION



¼ N ½ NE ¼ Section 3
Township 2 N [✓ S] Range 24 [✓ E] W
County Yellowstone
Lot 12 Block 8
Subdivision Collingwood
Well Elevation
Accuracy: ___ ± 10'; ___ ± 50'; ___ ± 100';

4. DRILLING METHOD ✓ cable, ___ bored, ___ forward rotary, ___ reverse rotary, ___ jetted, ___ other (specify)

5. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations and/or Screen: Kind Size	From (feet)	To (feet)
6"	6" 250 Steel	0	33			

Was casing left open end? ✓ Yes ___ No
Was a packer or seat used? ___ Yes ✓ No
If so, what material
Was the well gravel packed? ___ Yes ✓ No
Was the well grouted? ✓ Yes ___ No
To what depth? Below Pittless
Material used in grouting Cement
Well head completion: Pitless adapter ✓
12 in. above grade ✓, other
(if other, specify)
Pump horsepower 3, pump type Sub
Pump intake level 30 feet below land surface
Power (electric, diesel, etc.) Elec

6. WATER LEVEL
Static water level 25 feet below land surface
If flowing, closed-in pressure ___ psi
___ gpm flow through ___ inch pipe
Controlled by: ___ valve, ___ reducers, ___ other
(if other, specify)

7. WELL TEST DATA ✓ pump ✓ bailer ___ other
(if other, specify)
Pumping level below land surface:
27 ft. after 6 hrs. pumping 18 gpm
___ ft. after ___ hrs. pumping ___ gpm

8. WAS WELL PLUGGED OR ABANDONED? ___ Yes ✓ No
If yes, how?

9. DATE STARTED March 23
DATE COMPLETED March 24

10. WELL LOG

Depth (ft.) From	To	Formation
0	6	top soil
6	10	Rock
10	18	Sand
18	26	Brown Clay
26	33	Sand & Gravel

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BILLINGS OFFICE

HD

(use separate sheet if necessary)

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

March 24
Date

Beven Drilling
Firm Name

McLeod Montana 59052
Address

Thomas D Beven 294
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION
32 SOUTH EWING HELENA, MONTANA 59601 449-3634 **DNRC**

M:97980

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T. 1S R. 24E 34
County Yellowstone

MONTANA BUREAU OF MINES AND GEOLOGY
Butte, Montana

017417

(3)

WATER WELL LOG

Owner Jake K. Frank Address Rt. Laurel

Driller Clyde Sando Address 1141 Miles Ave Billings

Date Started May 21, 1960 Date Completed May 26, 19

Location: Sec. 34 T. 1S R. 24 ¼ sec. SE¼

Type of well Drilled (Dug, driven, bored, or drilled) Equipment used Cable (Churn drill, rotary, other)

Water use: Domestic ☐ Municipal ☐ Stock ☐ Irrigation ☐

Industrial ☐ Drainage ☐ Other: Dairy

Casing: 0 ft. to 56' 4" ft. Type 49lbs surface pipe Size 10 inch

Casing: ft. to ft. Type Size

Casing: ft. to ft. Type Size

Perforated or Screened: Ft. to ft. Ft. to ft.

Type of screen or perforations

Static Water level, for non-flowing well: feet

Shut-in pressure, for flowing well: lb./sq. in. on: (date)

Pumping water level feet at 100 gal. per min.

How tested: test pump

Length of test

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

(over)

Log of Well

Depth, feet		Description of Material Drilled
From	To	
0	10	gravel
10	50	sandy clay
50	55	soft coarse sand rock

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File No.

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T. 1S R. 24E 32

County Yellowstone

019225

(4)

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

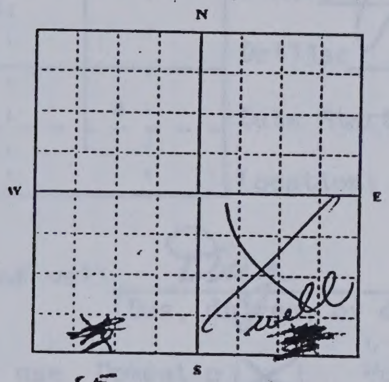
Declaration of Vested Groundwater Rights

(Under Chapter 237, Montana Session Laws, 1961)

1. Alex K Trask, of Rt 1 (Address) Laurel (Town)
(Name of Appropriator)

County of Yellowstone State of Mont.

have appropriated groundwater according to the Montana laws in effect prior to January 1, 1962, as follows:



SE ¼ ~~SE~~ SE Sec. 32 T. 1S R. 24E

Indicate point of appropriation and place of use, if possible. Each small square represents 10 acres.

2. The beneficial use on which the claim is based stock water

3. Date or approximate date of earliest beneficial use; and how continuous the use has been 1950

4. The amount of groundwater claimed (in miner's inches or gallons per minute) 20 gal

5. If used for irrigation, give the acreage and description of the lands to which water has been applied and name of the owner thereof not used

6. The means of withdrawing such water from the ground and the location of each well or other means of withdrawal not used at [illegible] present time

7. The date of commencement and completion of the construction of the well, wells, or other works for withdrawal of groundwater 1950

8. The depth of water table 40 feet

9. So far as it may be available, the type, size and depth of each well or the general specifications of any other works for the withdrawal of groundwater 8 in casing 43 feet deep

10. The estimated amount of groundwater withdrawn each year not used

11. The log of formations encountered in the drilling of each well if available 8 feet [illegible] 35 ft [illegible]

12. Such other information of a similar nature as may be useful in carrying out the policy of this act, including reference to book and page of any county record

Signature of Owner Alex K Trask

Date Dec 27, 1963

Three copies to be filed by the owner with the County Clerk and Recorder of the county in which the well is located.

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

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T. 2S R. 24E 4
COUNTY Yellowstone

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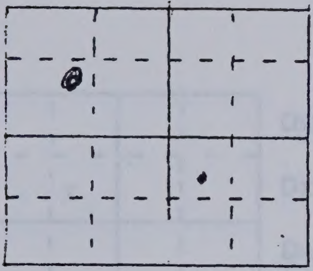
Butte, Montana

019742

Water Well Log



Owner R J Rosselot Address Laurel

Driller ______ Address ______

Date Started 1908 Date Completed ______

Location: Sec. 4 T. 2S R. 24E ¼ Sec. SW¼ of NW¼

Type of well Dug (Dug, driven, or drilled) Equipment used ______ (Churn drill, rotary, other)

Water use Domestic ☒ Municipal ☐ Stock ☒ Irrigation ☐

Industrial ☐ Drainage ☐ Other ______

Casing: ______ ft. to 50 ft. Type Stone Size 4 ft

Casing: ______ ft. to ______ ft. Type ______ Size ______

Casing: ______ ft. to ______ ft. Type ______ Size ______

Perforated or screened: Ft. ______ to ft. ______ Ft. ______ to ft. ______

Type of screen or perforations ______

Static water level, for non-flowing well: 40' feet.

Shut-in pressure for flowing well: ______ lb. /sq. in. on: ______ (date)

Pumping water level 45 feet at 20 gal. per min. ______

How tested: ______

Length of test ______

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

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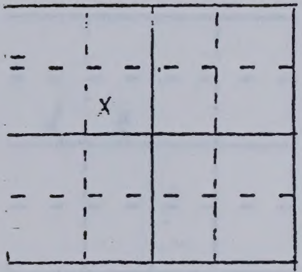
WATER WELL LOG



Owner Eugene Holland Address Rte 1 Laurel mont
Driller CA McKeehan Address Park City
Date Started 1957 Date Completed 1957
Location: Sec. 4 T. 2-S R. 24E ¼ Sec. SE¼ of NW¼

Type of well Drilled Equipment used Churn
(Dug, driven, or drilled) (Churn, drill, rotary other)

Water use Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☐
Industrial ☐ Drainage ☐ Other

Casing: 50 ft. to ft. Type Iron Size 6"
Casing: ft. to ft. Type Size
Casing: ft. to ft. Type Size

Perforated or ~~screened~~ Ft. 10 to ft. Ft. to Ft.
Type of screen or perforations Slit
Static water level, for non-flowing well: 20 feet.
Shut-in pressure for flowing well: lb./sq. in. on: (date)
Pumping water level 30 feet at 20 gal.per.min.
How tested:
Length of test
Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

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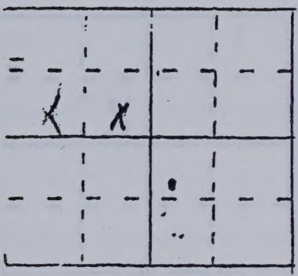
WATER WELL LOG



Owner James W Hill Address Rt 1 Box 15 Laurel mont

Driller C.A. McKeehan Address Park City

Date Started 1957 Date Completed 1957

Location: Sec. 4 T 2S R. 24E ¼ Sec. SE¼ of NW¼

Type of well Drilled (Dug, driven, or drilled) Equipment used Churn (Churn, drill, rotary other)

Water use Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☒
Industrial ☐ Drainage ☐ Other

Casing: 50 ft. to ft. Type Iron Size 6"

Casing: ft. to -ft. Type Size

Casing: ft. to ft. Type Size

Perforated or ~~screened~~ Ft. 10 to ft. Ft. to Ft.

Type of screen or perforations Slit

Static water level, for non-flowing well: 30 feet.

Shut-in pressure for flowing well: lb./sq. in. on: (date)

Pumping water level 40 feet at 50 gal.per.min.

How tested: Pump

Length of test 18 hrs

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

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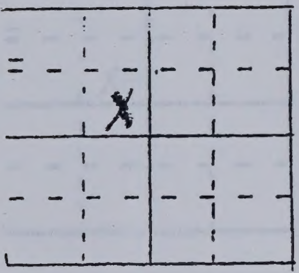
WATER WELL LOG



Owner John R Lees Address N of Laurel

Driller McKeehan Address Park City

Date Started 1957 Date Completed 1957

Location: Sec. 4 T. 2-S R. 24-E ¼ Sec SE¼ of NW¼

Type of well Drilled (Dug, driven, or drilled) Equipment used Churn drill (Churn, drill, rotary other)

Water use Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☒
Industrial ☐ Drainage ☐ Other

Casing: 0 ft. to 39 ft. Type Iron Size 6"
Casing: ft. to ft. Type Size
Casing: ft. to ft. Type Size

Perforated or screened Ft. 10 to ft. Ft. to Ft.

Type of screen or perforations holes cut in lower sec. of casing

Static water level, for non-flowing well: 16 feet.

Shut-in pressure for flowing well: lb./sq. in. on: (date)

Pumping water level 35 feet at 50 gal.per.min.

How tested: Driller tested with dip bucket

Length of test ?

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

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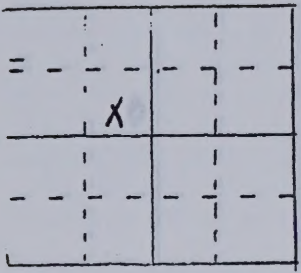
WATER WELL LOG



Owner H P Frank Address [illegible]
Driller C A Mc[illegible] Address [illegible]
Date Started 1958 Date Completed 1958
Location: Sec. 4 T. 2S R. 24E ¼ Sec. [illegible]

Type of well Drilled (Dug, driven, or drilled) Equipment used Churn (Churn, drill, rotary other)

Water use Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☑
Industrial ☐ Drainage ☐ Other ______

Casing: 50 ft. to ______ ft. Type [illegible] Size 6"
Casing: ______ ft. to ______ ft. Type ______ Size ______
Casing: ______ ft. to ______ ft. Type ______ Size ______

Perforated or screened Ft. [illegible] to ft. ______ Ft. ______ to Ft. ______

Type of screen or perforations [illegible]

Static water level, for non-flowing well: [illegible] feet.

Shut-in pressure for flowing well: ______ lb./sq. in. on: ______ (date)

Pumping water level 40 feet at [illegible] gal.per.min. ______

How tested: ______

Length of test ______

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

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Yellowstone

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T. 2 So. R. 24 E 4
County Yellowstone

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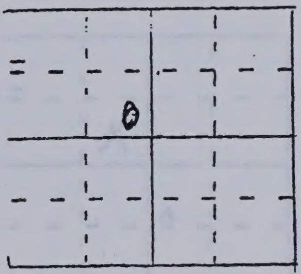
Butte, Montana

WATER WELL LOG



Owner J C Zuhlke Address Laurel

Driller / Address

Date Started Date Completed

Location: Sec. 4 T 2S R. 24E ¼ Sec. SE¼ of NW¼

Type of well (Dug, driven, or drilled) Equipment used (Churn, drill, rotary other)

Water use Domestic ☐ Municipal ☐ Stock ☐ Irrigation ☐

Industrial ☐ Drainage ☐ Other

Casing: 40 ft. to ft. Type Steel Size

Casing: ft. to ft. Type Size

Casing: ft. to ft. Type Size

Perforated or screened Ft. to ft. Ft. to Ft.

Type of screen or perforations 6"

Static water level, for non-flowing well: 23 feet.

Shut-in pressure for flowing well: lb./sq. in. on: (date)

Pumping water level 35 feet at 100 gal.per.min.

How tested: Pump tested

Length of test 24 hr

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

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T. 2-S R. 24E 4
County [illegible]

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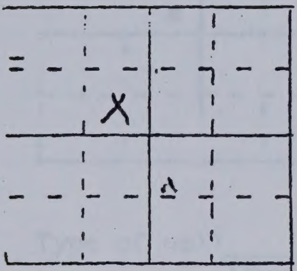
Butte, Montana

WATER WELL LOG



Owner E F [illegible] Address [illegible]
Driller [illegible] Address Billings
Date Started 1955 Date Completed 1955
Location: Sec. 4 T 2S R. 24E ¼ Sec. SE¼ of NW¼

Type of well [illegible] Equipment used Churn
(Dug, driven, or drilled) (Churn, drill, rotary other)

Water use Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☒
Industrial ☐ Drainage ☐ Other

Casing: 45 ft. to ft. Type [illegible] Size 6"
Casing: ft. to ft. Type Size
Casing: ft. to ft. Type Size
Perforated or screened Ft. 6 to ft. Ft. to Ft.
Type of screen or perforations
Static water level, for non-flowing well: 30 feet.
Shut-in pressure for flowing well: lb./sq. in. on: (date)
Pumping water level 40 feet at 18 gal.per.min.
How tested:
Length of test
Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

111 12S 24E 04BDD
Yellowstone

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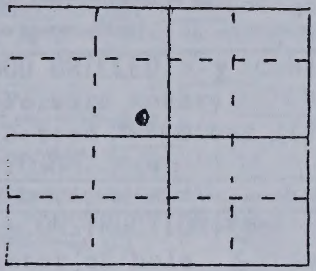
8-60

T. 2S R. 24E 4
COUNTY Yellowstone

MONTANA BUREAU OF MINES AND GEOLOGY
Butte, Montana

Water Well Log



Owner Burt L. and Cloanna M. Ward Address Rte 1, Laurel, Mont.

Driller Clyde Sando Address Billings, Montana

Date Started May 1959 Date Completed May 1959

Location: Sec. 4 T. 2S R. 24E ¼ Sec. SE 1/4 of NW 1/4

Type of well Driven (Dug, driven, or drilled) Equipment used Churn Drill (Churn drill, rotary other)

Water use Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☒

Industrial ☐ Drainage ☐ Other

Casing 0 ft. to 50 ft. Type XXXXX Steel Size 6"

Casing ft. to ft. Type Size

Casing ft. to ft. Type Size

Perforated or screened: Ft. to ft. Ft. to ft.

Type of screen or perforations

Static water level, for non-flowing well: Twenty five feet.

Shut-in pressure for flowing well: lb. /sq. in. on: (date)

Pumping water level 47 feet at 20 gal. per min.

How tested: Pump

Length of test two hours

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

Foot valve at 45 feet.

RM No. 603 New 7-73 111 025 24E 04 BD 1 Yellowstone File No. 6563-7138

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Mines & Geology

STATE OF MONTANA
Department of Natural Resources and Conservation

WELL LOG REPORT

WHITE —
PINK —
CANAR
GOLDENROD — DRILLER

017989

59044

State law requires that this form be filed by the water well driller on any water well completed by him on and after July 1, 1973 within sixty (60) days after completion of the well.

. WELL OWNER: Name **Wallace Hill** Address 1751 Cover Lane Laurel

. WELL LOCATION: County Yellowstone ; SE¼ NW¼ ¼, Sec. 4 , Twp. 25 N-S, Rg. 24E E-W

. PROPOSED USE: X Domestic ___ Stock ___ Municipal ___ Industrial ___ Lawn and Garden ___ Irrigation ___ Other (*if other, specify*)

. METHOD DRILLED: X Cable ___ Bored ___ Forward Rotary ___ Reverse Rotary ___ Jetted ___ Other (*if other, specify*)

. WELL CONSTRUCTION:
Diameter of hole 6 inches. Depth 100 ft.
Casing: X Steel ___ Plastic ___ Concrete
___ Threaded X Welded ___ Other (*if other, specify*)
Pipe Weight: Dia.: From: To:
___ lb/ft. 6 inches 0 feet 100 feet
___ lb/ft. ___ inches ___ feet ___ feet
___ lb/ft. ___ inches ___ feet ___ feet
Was perforated pipe used? X Yes ___ No
Length of pipe perforated 10 feet
Was casing left open end? X Yes ___ No
Was a well screen installed? ___ Yes X No
Material ___ Dia. ___ inches
(*stainless steel, bronze, etc.*)
Perforation type: X slots ___ holes
Size 8" set from 88 feet to 98 feet
Size ___ set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Was a packer or seal used? ___ Yes X No
If so, what material ___
Well type: ___ Straight screen ___ Graveled
Was the well grouted? ___ Yes X No
To what depth? ___ feet
Material used in grouting ___
Well head completion: Pitless adapter X
12" above grade ___ Other ___
(*If other, specify*)
Was the well disinfected? ___ Yes X No

6. WATER LEVEL:
Static water level 77 ft. below land surface
If flowing: closed-in pressure ___ psi
GPM flow ___ through ___ inch pipe
Controlled by: ___ Valve ___ Reducers
___ Other, *specify* ___

7. WELL TEST DATA: ___ Pump X Bailer ___ Other
(*If other, specify*)
Pumping level below land surface:
ft. after hrs. pumping gpm

8. WELL LOG: ELEV. 111CLVM 112ALVM

Depth (ft.) From	To	Formation
0	33	**Brown silt.**
33	73	**Gravel with silt in it.**
73	93	**Brown silt.**
93	95	**Sand.**
95	100	**Gravel with sand in it.**
100	-------	**Shale.**

(*Use separate sheet if necessary*)

9. DATE STARTED: **July 18, 1975**

10. DATE COMPLETED: **July 28, 1975**

11. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If so, how ___

12. DRILLER'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Ray Michels well drlg. 41
Driller's or Firm Name *License No.*

Box 421 Laurel, Mt.
Address

Kevin

111 02S 24E 04BCA
Yellowstone

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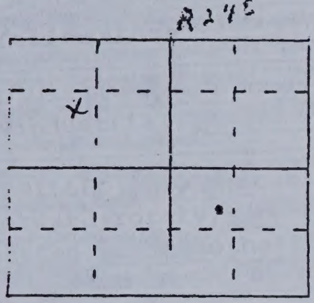


Water Well Log

Owner R J Rosselot Address Laurel

Driller Sando Address Billings

Date Started 1959 Date Completed 1960

Location: Sec. 4 T. 2S R. 24E ¼ Sec. SW¼ of NW¼

Type of well drilled (Dug, driven, or drilled) Equipment used drill (Churn drill, rotary, other)

Water use Domestic ☒ Municipal ☐ Stock ☒ Irrigation ☒

Industrial ☐ Drainage ☐ Other

Casing: ft. to 50' ft. Type steel pipe Size 6"

Casing: ft. to ft. Type Size

Casing: ft. to ft. Type Size

Perforated or screened: Ft. to ft. Ft. to ft.

Type of screen or perforations

Static water level, for non-flowing well: 24 feet.

Shut-in pressure for flowing well: lb. /sq. in. on: (date)

Pumping water level 50 feet at 20 gal. per min.

How tested: —

Length of test —

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

Foot valve at 50 ft

111 02S 24E 04 BCA Yellowstone 2S-24E-4BCA

No. 603 (Rev. 3/75)

File No. ____

STATE OF MONTANA
Department of Natural Resources and Conservation

017986
Gold-Driller

8558
943Q

②

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well, and Form 602, Notice of Completion of Groundwater Development, be filed by the well owner within 60 days after the water has been put to beneficial use.

WELL OWNER Name Gary Pfaff Current address 721 Wyoming, Laurel, MT

WELL LOCATION Lot ____, Block ____, Subdivision ____

County Yellowstone ____ ¼, or NE ¼ SW ¼ NW ¼ Sec. 4, T. 2 N-[✓ S] R. 24 [✓ E]-W

PROPOSED USE x domestic (includes lawn and garden); ____ stock; ____ municipal; ____ industrial; ____ irrigation; ____ other (specify) ____

METHOD DRILLED x cable, ____ bored, ____ forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify) ____

WELL CONSTRUCTION

Diameter of hole x in.; depth ____ ft.

Casing: x steel, ____ plastic, ____ concrete, ____ threaded, x welded, ____ other (specify)

Pipe weight:

	Dia.	From	To
17.02 lb/ft	6 5/8 in.	+2 ft.	112 ft.
lb/ft	in.	ft.	ft.

Was casing left open end? x Yes ____ No

Was a well screen installed? ____ Yes x No

Material ____, dia. ____ in.
(stainless steel, bronze, etc.)

Was perforated pipe used? x Yes ____ No

Perforation type: x slots ____ holes

Size 3/16 set from 108 ft. to 111 ft.

Size ____ set from ____ ft. to ____ ft.

Was a packer or seal used? ____ Yes x No

If so, what material ____

Well type: ____ Straight screen ____ Graveled

Was the well grouted: ____ Yes x No

To what depth: ____ ft.

Material used in grouting ____

Well head completion: Pitless adapter ____ 12 in. above grade x, other ____
(if other, specify) ____

Was well disinfected? ____ Yes x No

WATER LEVEL

Static water level 70 ft. below land surface

If flowing: closed-in pressure ____ psi

gpm flow ____ through ____ inch pipe

Controlled by: ____ valve ____ reducers ____ other (specify) ____

7 WELL TEST DATA ____ Pump x Bailer ____ Other ____
(if other, specify)

8. WELL LOG Two Pine School

111CLUM
110ALVM

No e/e

Depth (ft) From	To	Formation
0	7	top soil
7	112	sand & gravel

(use separate sheet if necessary)

9. DATE STARTED 5-3-76
DATE COMPLETED 5-13-76

10. WAS WELL PLUGGED OR ABANDONED? ____ Yes x No
If so, how? ____

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

B & H Drilling No. 27
Driller's or firm name License No.

Box 32 Fishtail, MT 59028
Address

11 02S 24E 04 B Yellowstone

FORM No. 603 New 7-73

Froshelle Heights Subdivision
Lot #16

Yellowstone 2S 24E 4 File No.

RECEIVED
OCT 23 1973
Montana Bureau of

STATE OF MONTANA
Department of Natural Resources and Conservation
WELL LOG REPORT

WHITE
PINK –
CANA
GOLDENROD — DRILLER

016847

State law requires that this form be filed by the water well driller on any water well completed by him on and after July 1, 1973 within sixty (60) days after completion of the well.

1. WELL OWNER: Name Dave Thor Address Laurel, Mont

2. WELL LOCATION: County Yellowstone ; ¼ ¼ NW ¼, Sec. 4, Twp. 2 N-[✓ S], Rg. 24 [✓ E]-W

3. PROPOSED USE: X Domestic ___ Stock ___ Municipal ___ Industrial X Lawn and Garden ___ Irrigation ___ Other (*if other, specify*) ___

4. METHOD DRILLED: X Cable ___ Bored ___ Forward Rotary ___ Reverse Rotary ___ Jetted ___ Other (*if other, specify*) ___

5. WELL CONSTRUCTION:

Diameter of hole 6 inches. Depth 109 ft.

Casing: X Steel ___ Plastic ___ Concrete ___ Threaded X Welded ___ Other (*if other, specify*) ___

Pipe Weight: Dia.: From: To:

8.97 lb/ft. 6⅝ inches 14 feet 109 feet

___ lb/ft. ___ inches ___ feet ___ feet

___ lb/ft. ___ inches ___ feet ___ feet

Was perforated pipe used? X Yes ___ No

Length of pipe perforated 4 feet

Was casing left open end? X Yes ___ No

Was a well screen installed? ___ Yes X No

Material ___ Dia. ___ inches (*stainless steel, bronze, etc.*)

Perforation type: X slots ___ holes

Size 1/8 X 6 set from 102 feet to 107 feet

Size ___ set from ___ feet to ___ feet

Size ___ set from ___ feet to ___ feet

Was a packer or seal used? ___ Yes ___ No

If so, what material ___

Well type: ___ Straight screen ___ Graveled

Was the well grouted? ___ Yes X No

To what depth? ___ feet

Material used in grouting ___

Well head completion: Pitless adapter ___ 12" above grade X Other ___ (*If other, specify*) ___

Was the well disinfected? X Yes ___ No

6. WATER LEVEL:

Static water level 80 ft. below land surface

If flowing: closed-in pressure ___ psi

GPM flow ___ through ___ inch pipe

Controlled by: ___ Valve ___ Reducers ___ Other, *specify* ___

7. WELL TEST DATA: ___ Pump X Bailer ___ Other (*If other, specify*) ___

Pumping level below land surface:

85 ft. after 3 hrs. pumping 30 gpm

___ ft. after ___ hrs. pumping ___ gpm

8. WELL LOG:

Depth (ft.)		Formation
From	To	
0	12	TOP Soil
12	93	Sand & Gravel Thin Clay lay
93	109	Sand + Gravel
		Two ft Plug left in
		buttom of Casing to Keep
		Sand & Gravel from heaving
		up the Hole!

(*Use separate sheet if necessary*)

9. DATE STARTED: 9-19-73

10. DATE COMPLETED: 9-26-73

11. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No

If so, how ___

12. DRILLER'S CERTIFICATION:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge. 328-3275

B & H Drilling 27
Driller's or Firm Name *License No.*

Fishtail, Mont
Address

Red L Haugan 9-29-73
Signed by *Date*

111-02S 24E 04B

Form No. 603 (Rev. 3/75)

File No. 74

White-Department
Pink-Bureau

017981

(3)

STATE OF MONTANA
Department of Natural Resources and Conservation

WELL LOG REPORT

10353
943Q

State law requires that this form be filed by the water well driller within 60 days after completion of the well, and Form 602, Notice of Completion of Groundwater Development, be filed by the well owner within 60 days after the water has been put to beneficial use.

1. WELL OWNER Name Fred Rodgers Current address 801 Second ave Laurel

2. WELL LOCATION Lot 19, Block 2, Subdivision Beartooth View
County Yellowstone or ___ ¼ ___ ¼ NW ¼ Sec. 4, T. 2 N-[✓ S] R. 24 [✓ E]-W

3. PROPOSED USE: ___ domestic (includes lawn and garden); ___ stock; ___ municipal; ___ industrial; ___ irrigation; ___ other (specify) MAR LAUREL

4. METHOD DRILLED ___ cable, ___ bored, X forward rotary, ___ reverse rotary, ___ jetted, ___ other (specify) ___

5. WELL CONSTRUCTION
Diameter of hole 6¼ in.; depth 130 ft.
Casing: ___ steel, X plastic, ___ concrete, ___ threaded, ___ welded, ___ other (specify)
Pipe weight:
Dia 4" From +1 To 130
260 lb/ft ___ in. ___ ft. ___ ft.
___ lb/ft ___ in. ___ ft. ___ ft.
Was casing left open end? ___ Yes ___ No
Was a well screen installed? ___ Yes X No
Material ___, dia. ___ in.
(stainless steel, bronze, etc.)
Was perforated pipe used? ___ Yes X No
Perforation type: ___ slots ___ holes
Size ___ set from ___ ft. to ___ ft.
Size ___ set from ___ ft. to ___ ft.
Was a packer or seal used? X Yes ___ No
If so, what material plastic
Well type: X Straight screen ___ Graveled
Was the well grouted: X Yes ___ No
To what depth: 14' ft.
Material used in grouting Bentonite
Well head completion: Pitless adapter ___
12 in. above grade X, other ___
(if other, specify) ___
Was well disinfected? ___ Yes ___ No

6. WATER LEVEL
Static water level 10 ft. below land surface
If flowing: closed-in pressure ___ psi
gpm flow ___ through ___ inch pipe
Controlled by: ___ valve ___ reducers
___ other (specify) ___

7. WELL TEST DATA: X Pump ___ Bailer ___ Other
(if other, specify) ___
Pumping level below land surface:
120 ft. after 8 hrs. pumping 15 gpm
___ ft. after ___ hrs. pumping ___ gpm

8. WELL LOG NO ELEV.

Depth (ft) From	To	Formation
0	3	top soil
3	33	Gravel
33	115	sand Clay
115	116	rock
116	130	sand Clay

ELEV 3323

~~[illegible]~~
~~24 CLRD~~
111CLVM.

(use separate sheet if necessary)

9. DATE STARTED 10-1-76
DATE COMPLETED 10-3-76

10. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If so, how? ___

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Rock Creek Drilling 380
Driller's or firm name License No.

PO Box 1141 Joliet Mont
Address

Wm Kuyper 10-18-76
Signed by date

111 .02S 24E 04B Yellowstone T2S-R24E-4

No. 603, New 7-73

File No.

rashelle Heights Subdivision
lat #12

STATE OF MONTANA
Department of Natural Resources and Conservation
WELL LOG REPORT

RECEIVED
OCT 23 1973

WHITE — DEPARTMENT
PINK —
CANARY
GOLDENROD —

017982

State law requires that this form be filed by the water well driller on any water well completed by him on and after July 1, 1973 within sixty (60) days after completion of the well.

WELL OWNER: Name Herman K. Frank Address Laurel, Mont
201 FOREST AVENUE

WELL LOCATION: County Yellowstone ; ___ ¼ ___ ¼ NW ¼, Sec. 4 , Twp. 2 N [✓ S], Rg. 24 [✓ E] W

PROPOSED USE: X Domestic ___ Stock ___ Municipal ___ Industrial X Lawn and Garden ___ Irrigation ___ Other (*if other, specify*) ___

METHOD DRILLED: X Cable ___ Bored ___ Forward Rotary ___ Reverse Rotary ___ Jetted ___ Other (*if other, specify*) ___

WELL CONSTRUCTION:
Diameter of hole X inches. Depth 105 ft.
Casing: X Steel ___ Plastic ___ Concrete ___ Threaded X Welded ___ Other (*if other, specify*) ___
Pipe Weight: Dia.: From: To:
797 lb/ft. 6 5/8 inches 1+ feet 100 feet
___ lb/ft. ___ inches ___ feet ___ feet
___ lb/ft. ___ inches ___ feet ___ feet
Was perforated pipe used? X Yes ___ No
Length of pipe perforated 4 feet
Was casing left open end? X Yes ___ No
Was a well screen installed? ___ Yes X No
Material ___ Dia. ___ inches
(*stainless steel, bronze, etc.*)
Perforation type: X slots ___ holes
Size 1/8 X 6 set from 95 feet to 99 feet
Size ___ set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Was a packer or seal used? ___ Yes X No
If so, what material ___
Well type: ___ Straight screen ___ Graveled
Was the well grouted? ___ Yes X No
To what depth? ___ feet
Material used in grouting ___
Well head completion: Pitless adapter X
12" above grade X Other ___
(*If other, specify*) ___
Was the well disinfected? X Yes ___ No

WATER LEVEL:
Static water level 80 ft. below land surface
If flowing: closed-in pressure ___ psi
GPM flow ___ through ___ inch pipe
Controlled by: ___ Valve ___ Reducers
___ Other, specify ___

WELL TEST DATA: ___ Pump X Bailer ___ Other
(*If other, specify*) ___
Pumping level below land surface:
85 ft. after 2 hrs. pumping 20 gpm
___ ft. after ___ hrs. pumping ___ gpm

8. WELL LOG:

Depth (ft.)		Formation
From	To	
0	2	TOP Soil
2	25	Sand + Gravel
25	91	Sand with Layers of Clay
91	99	Fine Sand + Gravel (water)
This is the only		
location on the plat.		

(*Use separate sheet if necessary*)

9. DATE STARTED: 9-14-73

10. DATE COMPLETED: 9-19-73

11. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If so, how ___

12. DRILLER'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

B + H Drilling 17
Driller's or Firm Name *License No.*

Fishtail, Mont
Address

Red L Haugen 9-29-73
Signed by *Date*

VII-02S 24E 04 B Yellowstone

Form No. 603 (Rev. 3/75) File No. 1000-942

RECEIVED
JAN 18 1978
MONT. DEPT. OF NATURAL RESOURCES & CONSERVATION

STATE OF MONTANA
Department of Natural Resources and Conservation

White-Department

017985 ner

CODED

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well, and Form 602, Notice of Completion of Groundwater Development, be filed by the well owner within 60 days after the water has been put to beneficial use.

1. WELL OWNER Name ______ Current address LAUREL-Mont

2. WELL LOCATION Lot 11, Block 1-2-3 Amended Subdivision Crockett Heights
County Yellowstone, or NW ¼ ___ ¼ ___ ¼ Sec. 4, T. 2 N-S, R. 24 E-W

3. PROPOSED USE X domestic (includes lawn and garden); ___ stock; ___ municipal; ___ industrial; ___ irrigation; ___ other (specify) ___

4. METHOD DRILLED ___ cable, ___ bored, X forward rotary, ___ reverse rotary, ___ jetted, ___ other (specify) ___

5. WELL CONSTRUCTION
Diameter of hole 7 7/8 in.; depth 100 ft.
Casing: ___ steel, X plastic, ___ concrete, ___ threaded, ___ welded, ___ other (specify) ___
Pipe weight: Plastic
___ lb/ft Dia. 5" in. From 0 ft. To 100 ft.
___ lb/ft ___ in. ___ ft. ___ ft.
___ lb/ft ___ in. ___ ft. ___ ft.
Was casing left open end? X Yes ___ No
Was a well screen installed? ___ Yes X No
Material ___, dia. ___ in.
(stainless steel, bronze, etc.)
Was perforated pipe used? X Yes ___ No
Perforation type: 1/8 slots ___ holes
Size 5 set from 95 ft. to 100 ft.
Size ___ set from ___ ft. to ___ ft.
Was a packer or seal used? X Yes ___ No
If so, what material Rubber & cement
Well type: ___ Straight screen ___ Graveled
Was the well grouted: ___ Yes X No
To what depth: ___ ft.
Material used in grouting ___
Well head completion: Pitless adapter X
12 in. above grade X, other ___
(if other, specify) ___
Was well disinfected? X Yes ___ No

6. WATER LEVEL
Static water level 25 ft. below land surface
If flowing: closed-in pressure ___ psi
___ gpm flow through ___ inch pipe
Controlled by: ___ valve ___ reducers
___ other (specify) ___

7. WELL TEST DATA ___ Pump X Bailer ___ Other
(if other, specify) ___
Pumping level below land surface:
95 ft. after 1 hrs. pumping 15 gpm
___ ft. after ___ hrs. pumping ___ gpm

8. WELL LOG

Depth (ft) From	To	Formation
0	9'	SOIL
9	20	mixed Gravel & clay
20	30	YELLOW CLAY
30	95	SHALE
95	100'	GRAVEL & SAND

(use separate sheet if necessary)

9. DATE STARTED 8/20/75
DATE COMPLETED 8/21/75

10. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If so, how? ___

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Roy D. Perel 170
Driller's or firm name License No.

Billings Mont
Address

Roy D. Perel 8/30/75
Signed by date

RM No. [illegible] 111 New 7-73 ~~X6902~~ 02S 24E 04B

File No.

YELLOWSTONE

Troshelle Heights Subdivision
Lot #16

STATE OF MONTANA
Department of Natural Resources and Conservation

WELL LOG REPORT

WHITE — DEPARTMENT
PINK — BUREAU
CANARY — WELL OWNER
GOLDENROD — DRILLER

State law requires that this form be filed by the water well driller on any 016127 *completed by him on and after July 1, 1973 within sixty (60) days after completion of the well.*

. WELL OWNER: Name Dave Thor ✓ Address Laurel, Mont

. WELL LOCATION: County Yellowstone ; ¼ ¼ NW¼, Sec. 4 , Twp. 2 N [✓ S], Rg. 24 [✓ E] W

. PROPOSED USE: X Domestic ___ Stock ___ Municipal ___ Industrial X Lawn and Garden ___ Irrigation ___ Other (*if other, specify*)

. METHOD DRILLED: X Cable ___ Bored ___ Forward Rotary ___ Reverse Rotary ___ Jetted ___ Other (*if other, specify*)

. WELL CONSTRUCTION:
Diameter of hole 6 inches. Depth 109 ft.
Casing: X Steel ___ Plastic ___ Concrete
___ Threaded X Welded ___ Other (*if other, specify*)
Pipe Weight: Dia.: From: To:
18.97 lb/ft. 6⅝ inches 1+ feet 109 feet
___ lb/ft. ___ inches ___ feet ___ feet
___ lb/ft. ___ inches ___ feet ___ feet
Was perforated pipe used? X Yes ___ No
Length of pipe perforated 4 feet
Was casing left open end? X Yes ___ No
Was a well screen installed? ___ Yes X No
Material ___ Dia. ___ inches
(*stainless steel, bronze, etc.*)
Perforation type: X slots ___ holes
Size 1/8 X 6 set from 102 feet to 107 feet
Size ___ set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Was a packer or seal used? ___ Yes ___ No
If so, what material
Well type: ___ Straight screen ___ Graveled
Was the well grouted? ___ Yes X No
To what depth? ___ feet
Material used in grouting
Well head completion: Pitless adapter
12" above grade X Other
(*If other, specify*)
Was the well disinfected? X Yes ___ No

. WATER LEVEL:
Static water level 80 ft. below land surface
If flowing: closed-in pressure ___ psi
GPM flow ___ through ___ inch pipe
Controlled by: ___ Valve ___ Reducers
___ Other, *specify*

7. WELL TEST DATA: ___ Pump X Bailer ___ Other
(*If other, specify*)
Pumping level below land surface:
85 ft. after 3 hrs. pumping 30 gpm
___ ft. after ___ hrs. pumping ___ gpm

8. WELL LOG:

Depth (ft.) From	Depth (ft.) To	Formation
0	12	TOP Soil
12	93	Sand + Gravel Thin Clay layer
93	109	Sand + Gravel
		Two ft Plug left in bottom of Casing to Keep Sand + Gravel from heaving up the Hole.

(*Use separate sheet if necessary*)

9. DATE STARTED: 9-19-73

10. DATE COMPLETED: 9-26-73

11. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If so, how

12. DRILLER'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

328-3275

B & H Drilling — 27
Driller's or Firm Name — License No.

Fishtail, Mont
Address

Red L Haugan — 9-29-73
Signed by — Date

SW

File No. 111 02S 24E 04B

TRIPLICATE Yellowstone

RECEIVED
AUG 5 1966
Montana Bureau of Mines and Geology

1

T 2S R 24E 4

County Yellowstone

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

017983

Notice of Completion of Groundwater Appropriation by Means of Well

(Under Chapter 237, Montana Session Laws, 1961)

Top of Ground
(Elev. above sea level 3280)

first 27 ft gravel
27-36 sand and gravel
36-65 yellow clay
65-78 sand
78-96 gravel

Owner Rudy Groshell Address Laurel-mont

Driller Adolph Koenig Address Belleigymont

Date of Notice of Appropriation of Groundwater June 4-66

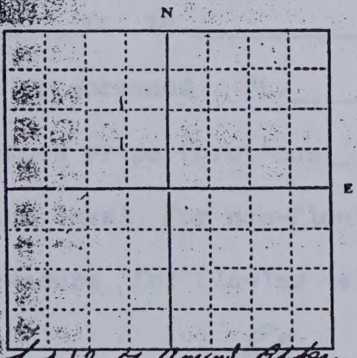
Date well started June 20 Date Completed June 24-66

Type of well drilled (dug, driven, bored or drilled) Equipment Used cable Tool (Churn, drill, rotary or other)

Water Use: Domestic ☒ Municipal ☐ Other ☐ Irrigation ☐ Industrial ☐ Drainage ☐ Stock ☐

☞ Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS		
				Kind Size	From (Feet)	To (Feet)
6 3/4	15 1/2 lb	top	96	none	none	( )



Lot 12 of Ground [illegible] 1Tr3 Groshell Hgts Sub

NW¼ Sec. 4 T. 2S R. 24E

Indicate location of well and place of use, if possible. Each small square represents 10 acres.

96 Show exact depth of bottom.

Static Water Level for non-flowing Well 70 ft from Surface feet.

Shut-in Pressure for Flowing Well none

Pumping Water Level 80 ft from Surface feet at 15 gal. per minute.

Discharge in gal. per min. of flowing well none

How Tested bailer and pump Length of Test 3 hrs

Remarks: (Gravel packing, cementing, packers, type of shutoff, location of place of use of groundwater if not at well, and any other similar pertinent information, including number of acres irrigated, if used for irrigation) none

A 132
Driller's License Number

Adolph Koenig
Driller's Signature

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located.

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

Original to the County Clerk and Recorder; duplicate to the State Engineer; Triplicate to the Montana Bureau of Mines and Geology and Quadruplicate for the Appropriator.

111 02S 24E 04BB
Yellowstone

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JAN - 3 1982
Montana Bureau of
Mines and Geology

(4)

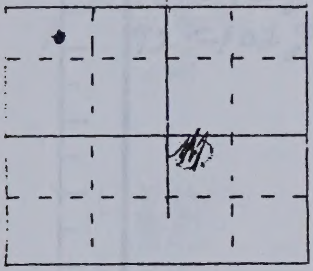
019741

Form No. 18
8-60

T. 2S R. 24E 4
COUNTY Yellowstone

MONTANA BUREAU OF MINES AND GEOLOGY
Butte, Montana

Water Well Log



Owner R P Rosselot Address Laurel

Driller [illegible] Address Billings

Date Started 4-1-47 Date Completed 4-7-47

Location: Sec. 4 T. 2S R. 24E ¼ Sec. NW¼ of NW¼

Type of well drilled Equipment used drill
(Dug, driven, or drilled) (Churn drill, rotary, other)

Water use Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☒

Industrial ☐ Drainage ☐ Other

Casing: ft. to 75' ft. Type metal Size 4"

Casing: ft. to ft. Type Size

Casing: ft. to ft. Type Size

Perforated or screened: Ft. to ft. Ft. to ft.

Type of screen or perforations

Static water level, for non-flowing well: feet.

Shut-in pressure for flowing well: lb. /sq. in. on: (date)

Pumping water level 50 feet at 20 gal. per min.

How tested:

Length of test

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

Foot value @ 50 ft

111 02S 24E 04B[illegible]C

File No. Yellowstone

TRIPLICATE

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OCT 7 1966
Montana Bureau of Mines and Geology

①

T 2S R 24E 4

County Yellowstone

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER
OFFICE OF STATE ENGINEER

017990

Top of Ground
(Elev. above sea level 3290)

first 34 - ft Sand and gravel
34 = 56 yellow clay
56 = 78 Sand and clay
78 = 92 yellow clay
92 = 102 gravel

Notice of Completion of Groundwater Appropriation by Means of Well

(Under Chapter 237, Montana Session Laws, 1961)

Owner Kennith Christen Address Laurel mont

Driller Adolph Koenig Address Billings

Date of Notice of Appropriation of Groundwater July 15-66

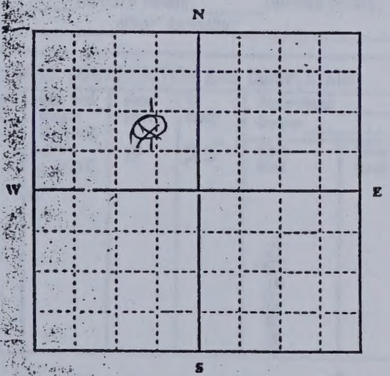
Date well started July 24 Date Completed Aug 1-66

Type of well drilled (dug, driven, bored or drilled) Equipment Used Cable Tool (Churn, drill, rotary or other)

Water Use: Domestic ☒ Municipal ☐ Other ☐ Irrigation ☐ Industrial ☐ Drainage ☐ Stock ☐

☞ Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS		
				Kind Size	From (Feet)	To (Feet)
6 in	6 I.D. 15 lb	top	102	none	none	none



SW1/4NW Sec. 4 T2S R24E

Indicate location of well and place of use, if possible. Each small square represents 10 acres.

Show exact depth of bottom.

102

Static Water Level for non-flowing Well 64 feet.

Shut-in Pressure for Flowing Well none

Pumping Water Level 80 feet at 15 gal. per minute.

Discharge in gal. per min. of flowing well none

How Tested Bailer Length of Test 2 1/2 hr

Remarks: (Gravel packing, cementing, packers, type of shutoff, location of place of use of groundwater if not at well, and any other similar pertinent information, including number of acres irrigated, if used for irrigation)

165
Driller's License Number

Adolph Koenig
Driller's Signature

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located.

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

Original to the County Clerk and Recorder; duplicate to the State Engineer; Triplicate to the Montana Bureau of Mines and Geology and Quadruplicate for the Appropriator.

Form No. 603 R10/79 111 02S 24E 03 A Yellowstone File No. C30648

Log Filmed

016108

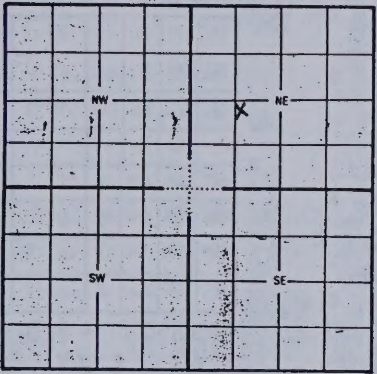
WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after complet[illegible] the well.

1. WELL OWNER
Name Larry Wyman

2. CURRENT MAILING ADDRESS
116 6th ave Laurel Montana

3. WELL LOCATION



____ ¼ N ½ ¼ NE ¼ Section 3
Township 2S N/S Range 24 E E/W
County Yellowstone
Lot 7 Block 1
Subdivision COLLING WOOD
Well Elevation ____
Accuracy: ____ ± 10'; ____ ± 50'; [✓ ± 100'];

4. DRILLING METHOD [✓ cable]; ____ bored, ____ forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify) ____

5. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)
6"	250 STEEL 6"	0	25

Perforations ____ and/or Screen ____

Kind Size	From (feet)	To (feet)

Was casing left open end? [✓ Yes] ____ No
Was a packer or seal used? ____ Yes [✓ No]
If so, what material ____
Was the well gravel packed? ____ Yes [✓ No]
Was the well grouted? ____ Yes [✓ No]
To what depth? ____
Material used in grouting ____
Well head completion: Pitless adapter ____
[✓ 12 in. above grade], ____ other ____
(If other, specify) ____
Pump horsepower ____, pump type ____
Pump intake level ____ feet below land surface
Power (electric, diesel, etc.) ____

6. WATER LEVEL
Static water level 12 feet below land surface
If flowing, closed-in pressure ____ psi
____ gpm flow through ____ inch pipe
Controlled by: ____ valve, ____ reducers, ____ other
(If other, specify) ____

7. WELL TEST DATA ____ pump [✓ bailer] ____ other
(If other, specify) ____
Pumping level below land surface:
18 ft. after ____ hrs. pumping 12 gpm
____ ft. after ____ hrs. pumping ____ gpm

8. WAS WELL PLUGGED OR ABANDONED? ____ Yes [✓ No]
If yes, how? ____

9. DATE STARTED 23 June 1980
DATE COMPLETED 26 June 1980

10. WELL LOG

Depth (ft.) From	To	Formation
0	7	top soil
7	15	Rock & Gravel
15	25	SAND & Gravel
25	40	Shale

(use separate sheet if necessary)

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

June 29 1980
Date

Beven Drilling
Firm Name

1113 St Johns ave Billings
Address

Thomas D Beven 294
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION **DNRC**
32 SOUTH EWING HELENA, MONTANA 59601 449-3634

GW 4

File No. 111 02S 24E 03 BBB

T 2 S. R 24 E. 3

TRIPLICATE Yellowstone

County Yellowstone

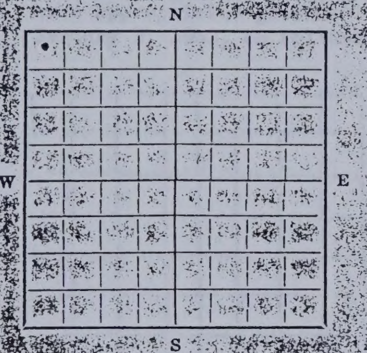
019737

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

Declaration of Vested Groundwater Rights

(Under Chapter 237, Montana Session Laws, 1961)

1. Henry Foos (Name of Appropriator), of Box ~~XXX~~ 252 Rte. #1 (Address) Laurel (Town)
County of Yellowstone State of Montana
have appropriated groundwater according to the Montana laws in effect prior to January 1, 1962, as follows:



NW ¼ Sec. ~~XX~~ 3 T 2S R 24 E.

Indicate point of appropriation and place of use, if possible. Each small square represents 10 acres.

2. The beneficial use on which the claim is based Home and cattle
3. Date or approximate date of earliest beneficial use; and how continuous the use has been 1941 continuous
4. The amount of groundwater claimed (in miner's inches or gallons per minute) 10 gallons per minute
5. If used for irrigation, give the acreage and description of the lands to which water has been applied and name of the owner thereof none
6. The means of withdrawing such water from the ground and the location of each well or other means of withdrawal pump, electric motor
7. The date of commencement and completion of the construction of the well, wells, or other works for withdrawal of groundwater 1941
8. The depth of water table 45 ~~XX~~ feet
9. So far as it may be available, the type, size and depth of each well or the general specifications of any other works for the withdrawal of groundwater 6" casing 70' depth
10. The estimated amount of groundwater withdrawn each year 900,000
11. The log of formations encountered in the drilling of each well if available Not Avaliable
12. Such other information of a similar nature as may be useful in carrying out the policy of this act, including reference to book and page of any county record None

Signature of Owner Henry Foos

Date December 10, 1962

Three copies to be filed by the owner with the County Clerk and Recorder of the county in which the well is located.

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

Original to the County Clerk and Recorder; duplicate to the State Engineer; Triplicate to the School of Mines and Quadruplicate for the Appropriator.

111 . 01S 24E 29BC Yellowstone

File No..................

T. 1S R. 24E. 29

County Yellowstone

019220

ORIGINAL
RECEIVED
JAN 2 1964
Montana Bureau of
Mines and Geology

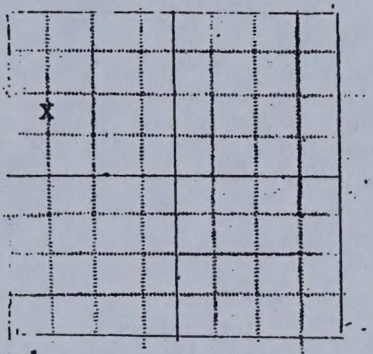
STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

(4)

DECLARATION of VESTED GROUNDWATER RIGHTS
(Under Chapter 237, Montana Session Laws, 1961)

1. Jake W. Kukes, of Laurel
(Name of Appropriator) (Address) (Town)

County of Yellowstone State of Montana
have appropriated groundwater according to the Montana laws in effect prior to January 1, 1962, as follows:



NW¼ - ¼ - Sec. 29 T. 1S R. 23E.
Indicate point of appropriation and place of use, if possible. Each small square represents 10 acres.

2. The beneficial use on which the claim is based dug well - domestic and livestock

3. Date or approximate date of earliest beneficial use; and how continuous the use has been 1947 continuous

4. The amount of groundwater claimed (in miner's inches or gallons per minute 25 gallons

5. If used for irrigation, give the acreage and description of the lands to which water has been applied and name of the owners thereof not applicable

6. The means of withdrawing such water from the ground and the location of each well or other means of withdrawal piped - pump

7. The date of commencement and completion of the construction of the well, wells, or other works for withdrawal of groundwater 1947 - piped & pumped

8. The depth of water table 18 feet

9. So far as it may be available, the type, size and depth of each well or the general specifications of any other works for the withdrawal of groundwater not applicable

10. The estimated amount of groundwater withdrawn each year 11,169,000 gallons

11. The log of formations encountered in the drilling of each well if available not known

12. Such other information of a similar nature as may be useful in carrying out the policy of this act, including reference to book and page of any county record well used since homestead

Signature of Owner x

Date December 21, 1963

Three copies to be filed by the owner with the County Clerk and Recorder of the county in which the well is located.

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

Original to the County Clerk & Recorder; Duplicate to the State Engineer; Triplicate to the Montana Bureau of mines and Geology, and Quadruplicate for the appropriator

APPENDIX B

LOGS OF TEST BORINGS

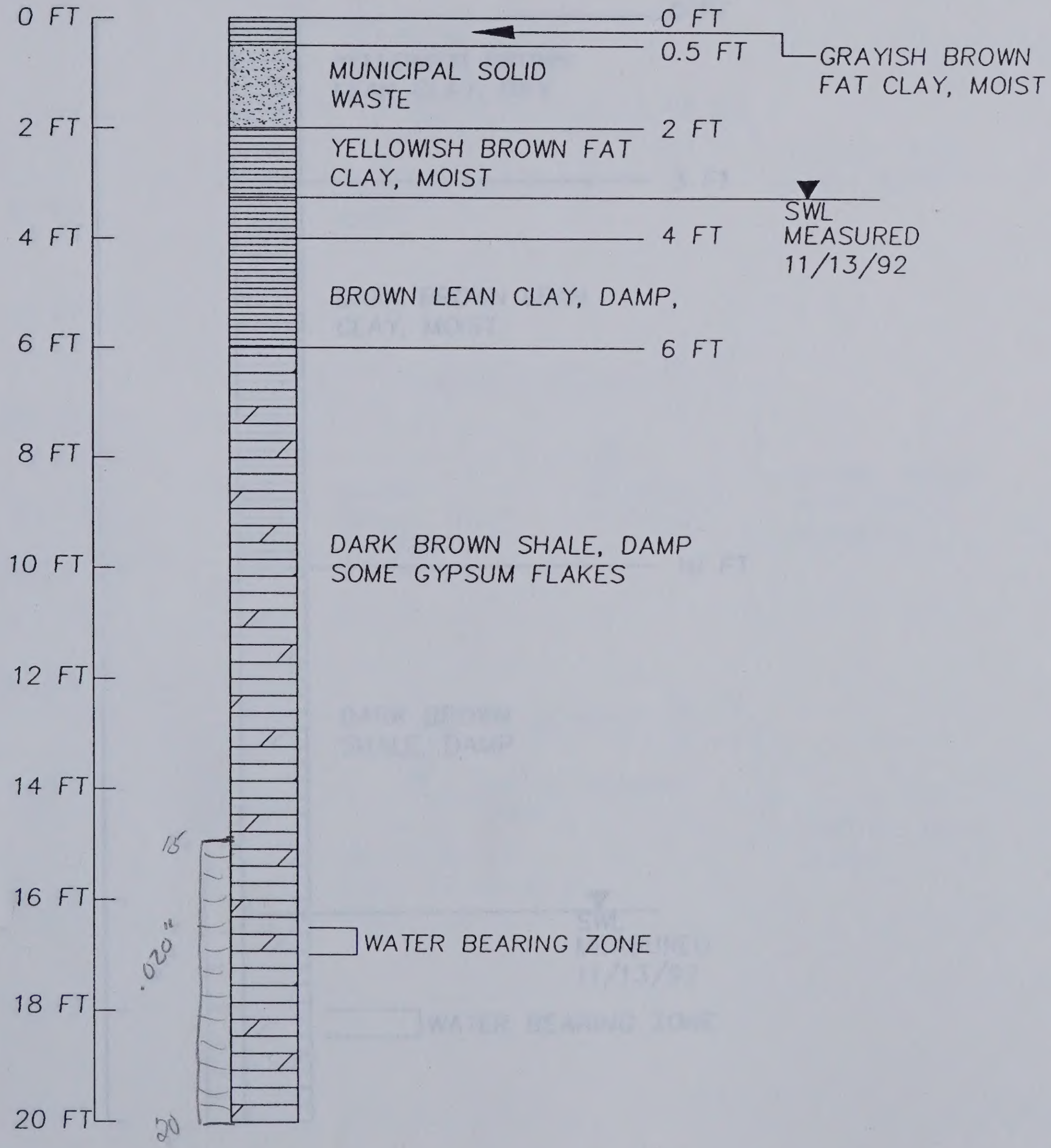
LITHOLOGIC LOG OF WELL BOREHOLE

PROJECT NUMBER 112035
SITE LAUREL LANDFILL
LOCATION LAUREL, MT
T1S, R24E, SECS 32 & 33

SUPERVISOR CURT COOVER
GEORESEARCH, INC.
DRILLER PRO PUMP
DATE OCTOBER 27, 1992

HOLE I.D.
MW-1

LITHOLOGY



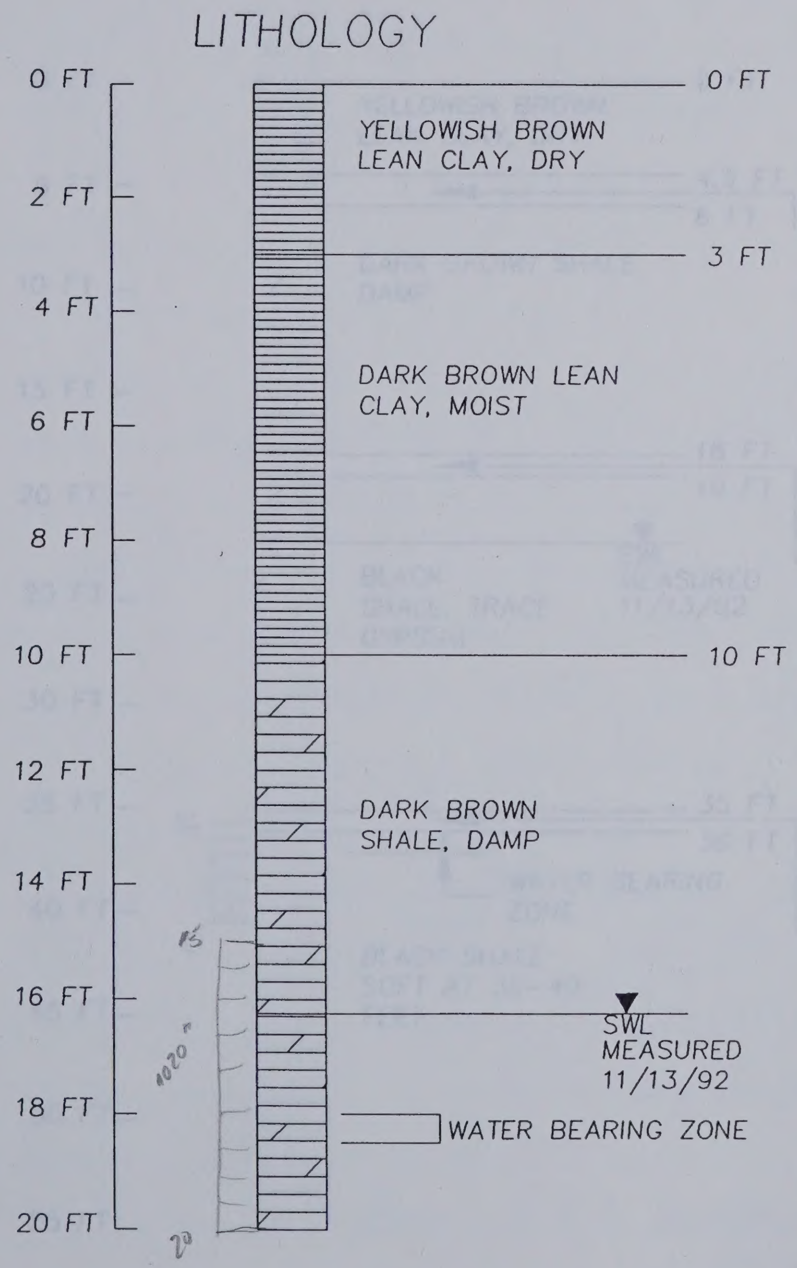
GEO
RESEARCH

LITHOLOGIC LOG OF WELL BOREHOLE

PROJECT NUMBER 112035
SITE LAUREL LANDFILL
LOCATION LAUREL, MT
T1S, R24E, SECS 32 & 33

SUPERVISOR CURT COOVER
GEORESEARCH, INC.
DRILLER PRO PUMP
DATE OCTOBER 27, 1992

HOLE I.D.
MW-2



GEO
RESEARCH

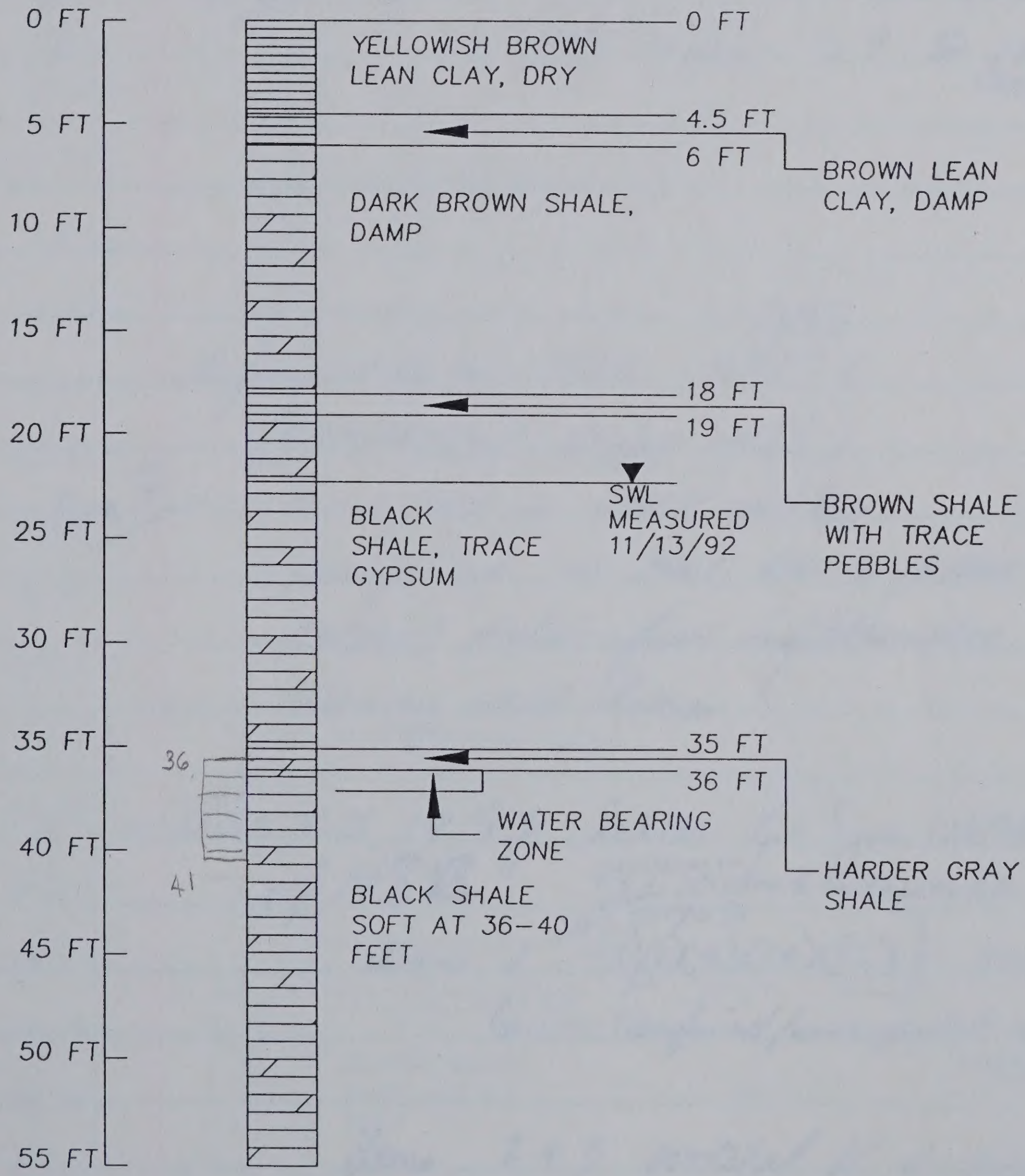
LITHOLOGIC LOG OF WELL BOREHOLE

PROJECT NUMBER 112035
SITE LAUREL LANDFILL
LOCATION LAUREL, MT
T1S, R24E, SECS 32 & 33

SUPERVISOR CURT COOVER
GEORESEARCH, INC.
DRILLER PRO PUMP
DATE OCTOBER 27, 1992

HOLE I.D.
MW-3

LITHOLOGY



GEO
RESEARCH

letter dated March 10, 1994
to David Michael
" Soil Sampling for Analysis of Nitrates"

No Map of sample locs. → 14 soil samples –
3" to 21" below graded land surf.
on #203 highest: P-2 1.7 to 15.8 ppm (? incr w/depth?
"BN" 40 paces 7.7 to 10.5 (deeper) ppm

HSS
deficiencies in 1992 HHS:
(additional deeper well)
Geo R slug tst in new well(s)
pump tst in MW1, MW-2, + MW 3
collect data from infiltrometer R-1
survey well locs

~ Mar 26, 1993 letter to Jim Worthington - "review of HSB" concern w/ thin screened intervals (ie 5')
items 1 → 703 (1)(a)(v)(C) vertical + horiz flow
6 confined/unconfined w/ storativity values ~~transmissivity calcs.~~

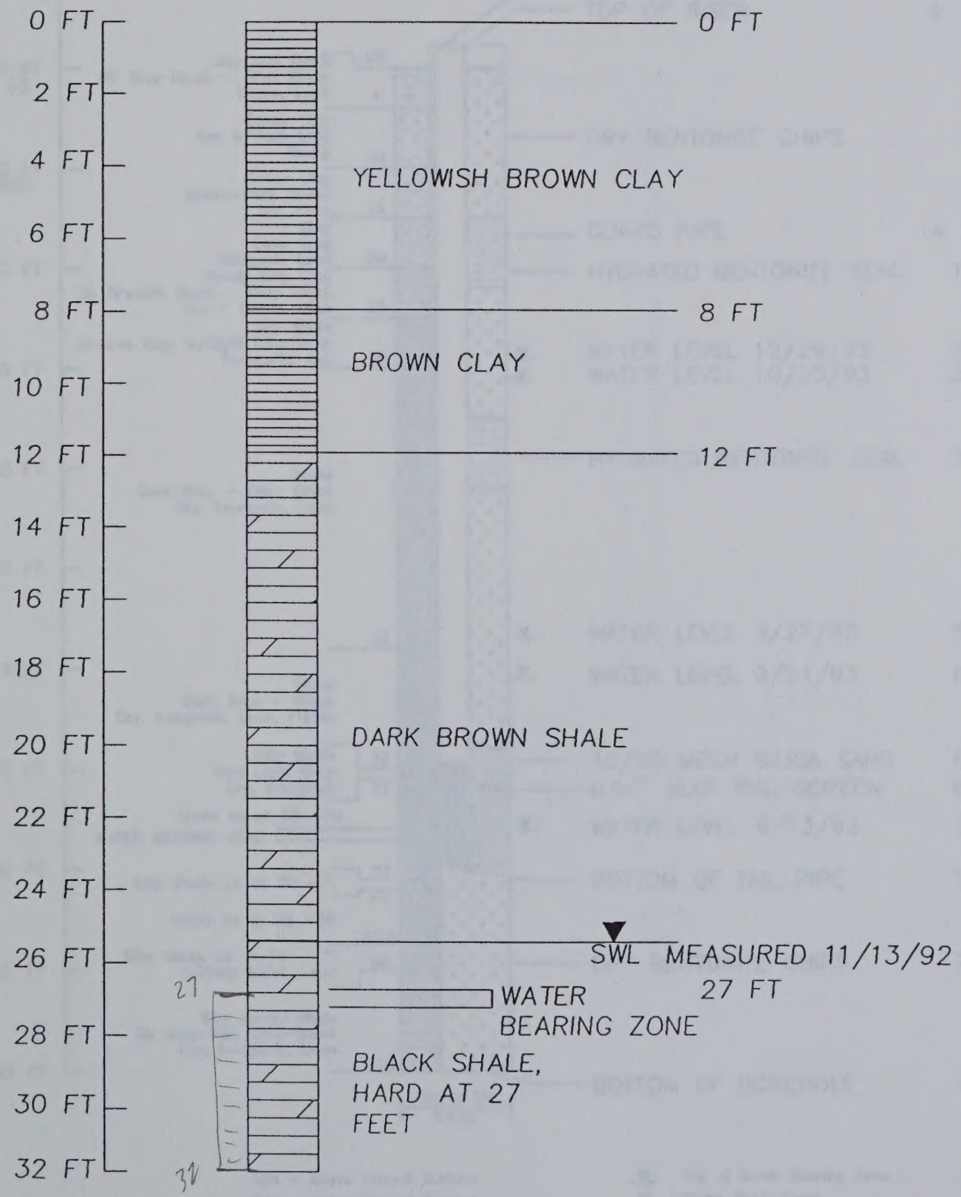
items 2 + 3 vertical K is inconclusive
8x10^{-8} cm/sec

heads differ → ? gradient provided = .012

LITHOLOGIC LOG OF WELL BOREHOLE

PROJECT NUMBER 112035 SITE LAUREL LANDFILL LOCATION LAUREL, MT T1S, R24E, SECS 32 & 33	SUPERVISOR CURT COOVER GEORESEARCH, INC. DRILLER PRO PUMP DATE OCTOBER 28, 1992	HOLE I.D. MW-4

LITHOLOGY



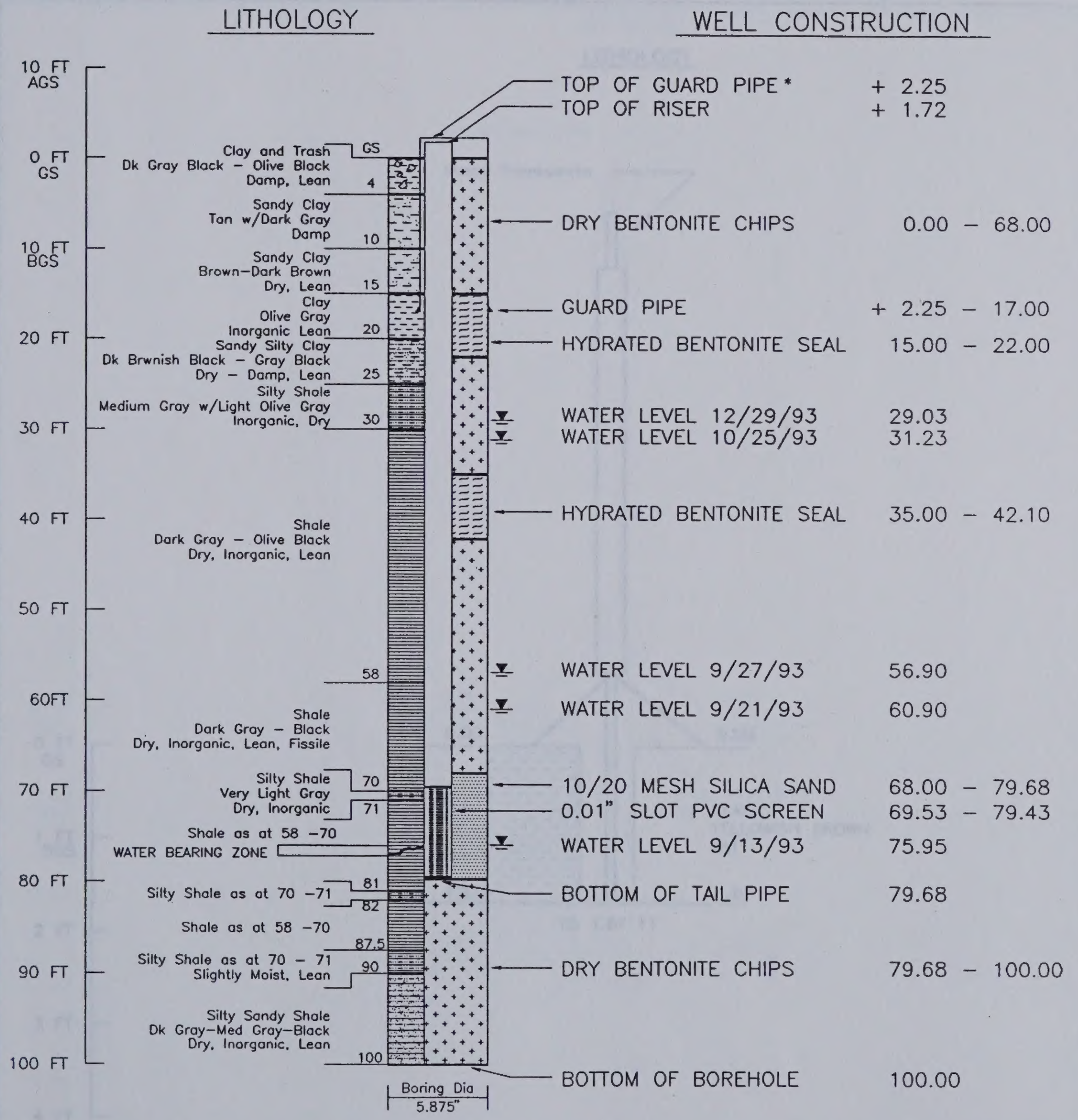
GEO RESEARCH

LITHOLOGY AND WELL COMPLETION LOG

PROJECT NUMBER 112035
SITE LAUREL LANDFILL
LOCATION NW S33 T1S R24E
YELLOWSTONE COUNTY, MT
MP ELEV 3549.93 FT MSL TOGP*

SUPERVISOR J. D. SHAFFER
GEORESEARCH, INC
DRILLER ADT PRO PUMP
DATE DRILLED September 10, 1993
DATE CONSTRUCTED September 10, 1993

BORE HOLE
93MW-2D



TOP OF GUARD PIPE*	+ 2.25
TOP OF RISER	+ 1.72
DRY BENTONITE CHIPS	0.00 – 68.00
GUARD PIPE	+ 2.25 – 17.00
HYDRATED BENTONITE SEAL	15.00 – 22.00
WATER LEVEL 12/29/93	29.03
WATER LEVEL 10/25/93	31.23
HYDRATED BENTONITE SEAL	35.00 – 42.10
WATER LEVEL 9/27/93	56.90
WATER LEVEL 9/21/93	60.90
10/20 MESH SILICA SAND	68.00 – 79.68
0.01" SLOT PVC SCREEN	69.53 – 79.43
WATER LEVEL 9/13/93	75.95
BOTTOM OF TAIL PIPE	79.68
DRY BENTONITE CHIPS	79.68 – 100.00
BOTTOM OF BOREHOLE	100.00

AGS – Above Ground Surface
BGS – Below Ground Surface
All dimensions in Feet Below Ground Surface

▽ Top of Water Bearing Zone
▼ Static Water Level
TD – Total Depth

GEO RESEARCH

LITHOLOGIC LOG OF GUELPH BORING

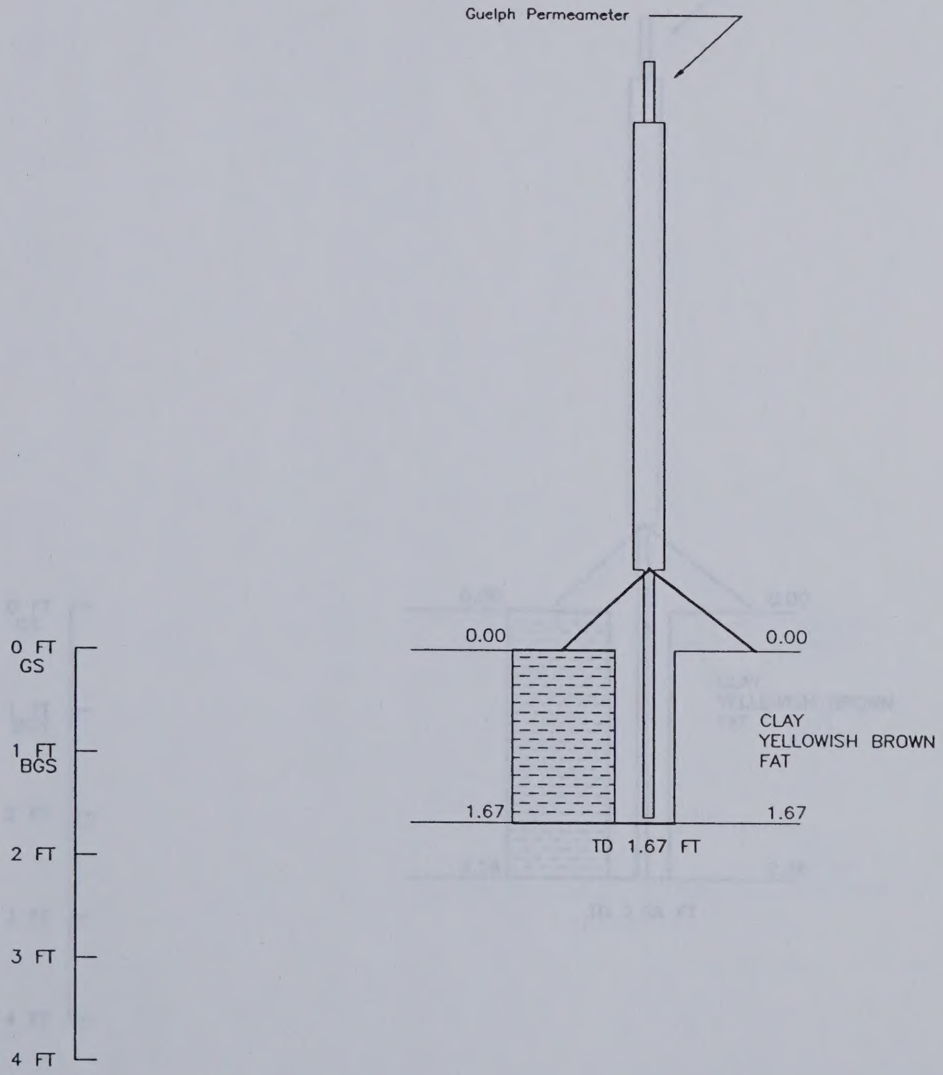
PROJECT NUMBER 112035
SITE LAUREL LANDFILL
LOCATION NW S33 T1S R24E
YELLOWSTONE COUNTY, MT
EAST SIDE OF LANDFILL

SUPERVISOR CURT COOVER
GEORESEARCH, INC

DATE AUGERED October 30, 1992

BORING
G-1

LITHOLOGY



BGS – Below Ground Surface
All dimensions in Feet Below Ground Surface

▽ Top of Water Bearing Zone
TD – Total Depth

GEO RESEARCH

LITHOLOGIC LOG OF GUELPH BORING

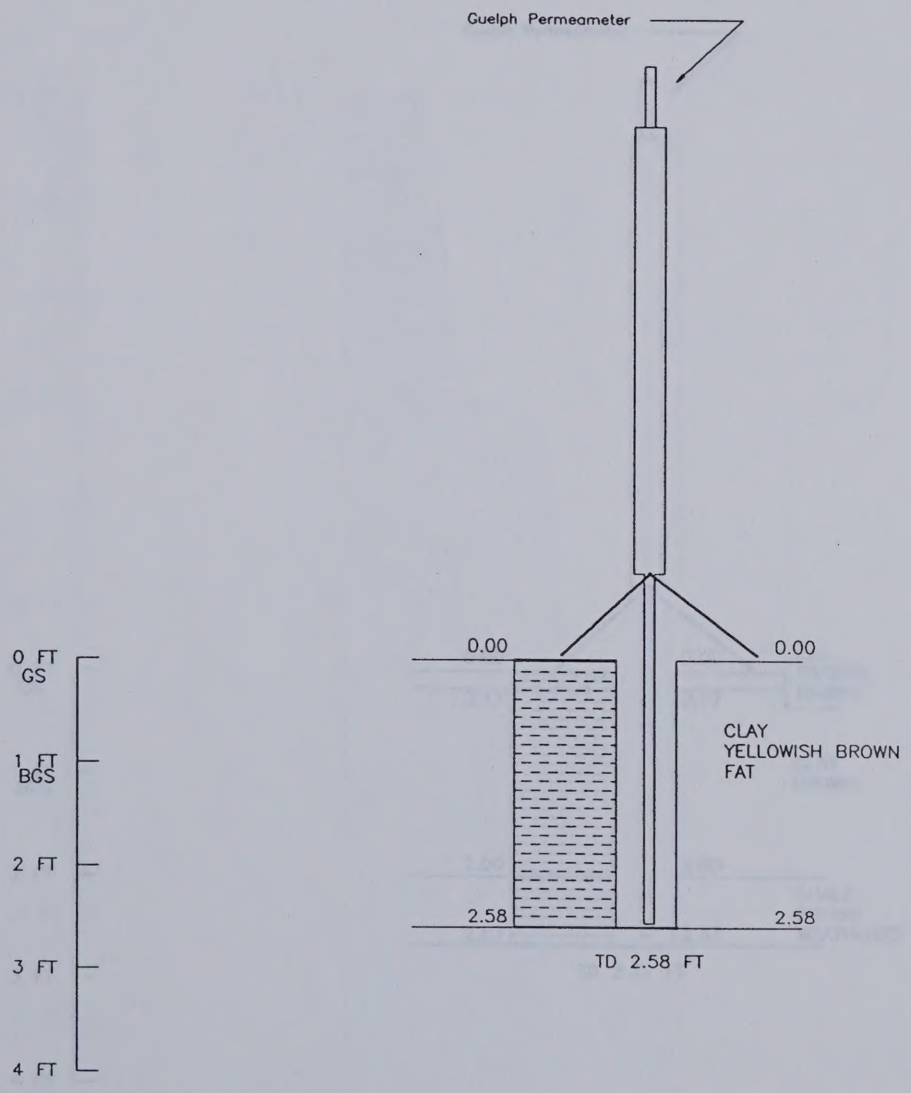
PROJECT NUMBER 112035
SITE LAUREL LANDFILL
LOCATION NW S33 T1S R24E
YELLOWSTONE COUNTY, MT
NORTHWEST CORNER OF LANDFILL

SUPERVISOR CURT COOVER
GEORESEARCH, INC

DATE AUGERED November 14, 1992

BORING
G-2

LITHOLOGY



BGS – Below Ground Surface
All dimensions in Feet Below Ground Surface

▽ Top of Water Bearing Zone
TD – Total Depth

GEO
RESEARCH

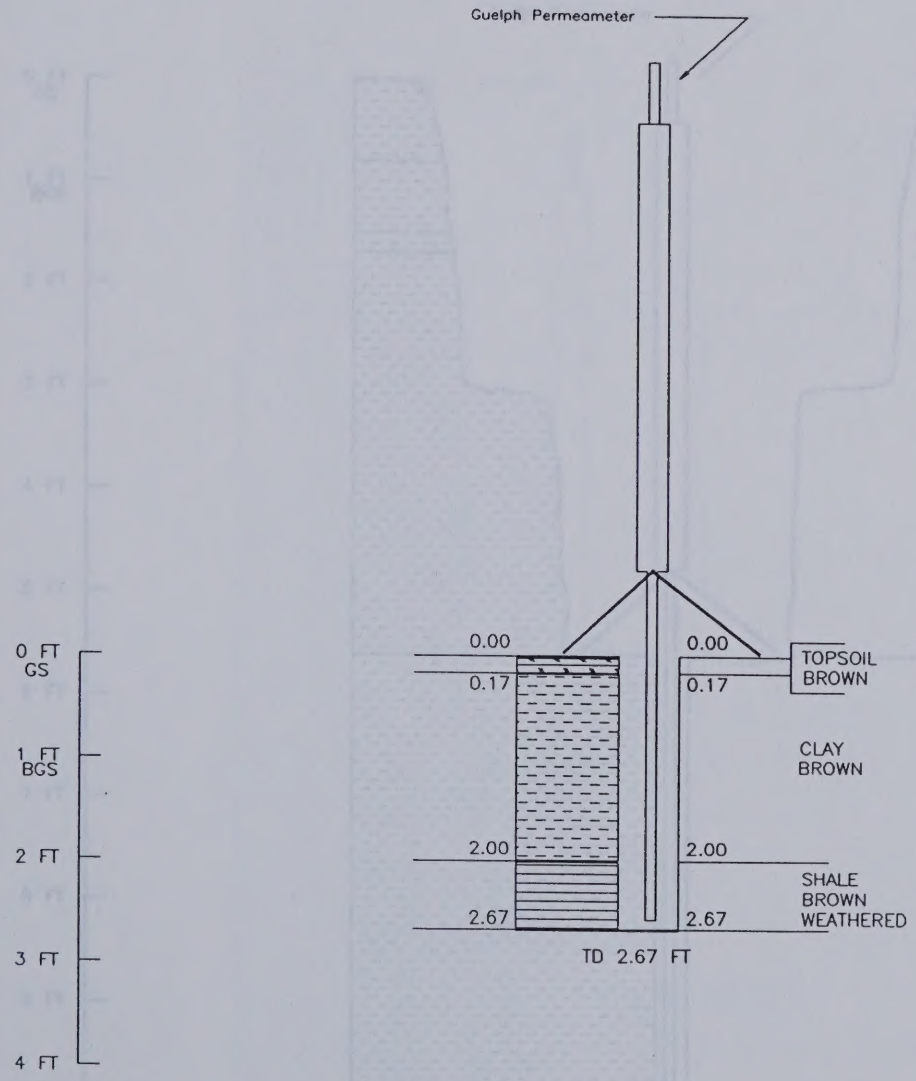
LITHOLOGIC LOG OF GUELPH BORING

PROJECT NUMBER 112035
SITE LAUREL LANDFILL
LOCATION NW S33 T1S R24E
YELLOWSTONE COUNTY, MT
SOUTH SIDE OF LANDFILL

SUPERVISOR CURT COOVER
GEORESEARCH, INC
DATE AUGERED November 14, 1992

BORING
G-3

LITHOLOGY



BGS – Below Ground Surface
All dimensions in Feet Below Ground Surface

▽ Top of Water Bearing Zone
TD – Total Depth

GEO
RESEARCH

LITHOLOGIC LOG OF GUELPH BORING

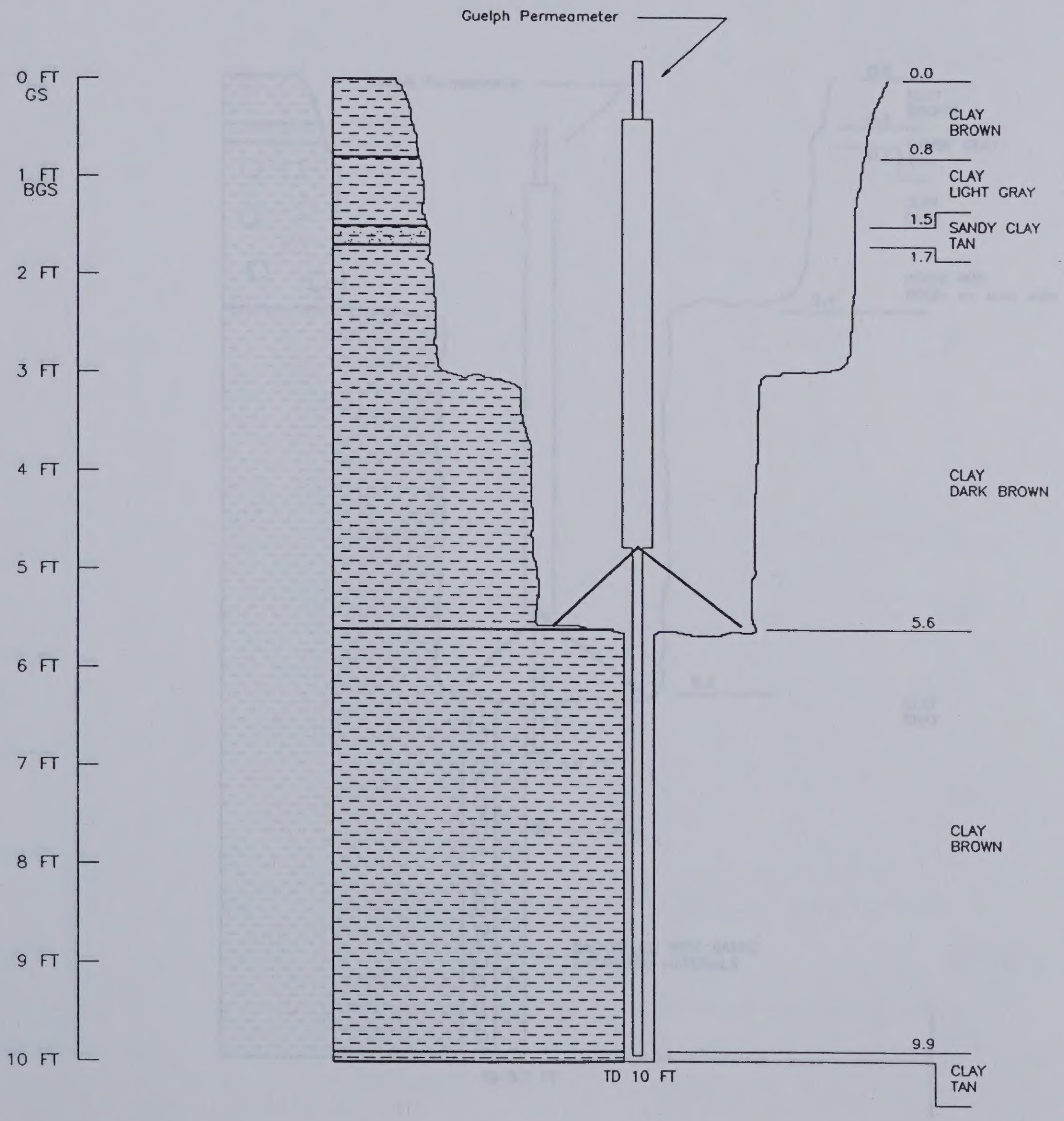
PROJECT NUMBER 112035
SITE LAUREL LANDFILL
LOCATION NW S33 T1S R24E
YELLOWSTONE COUNTY, MT
SOUTH SIDE OF LANDFILL

SUPERVISOR M. M. HOFACKER
GEORESEARCH, INC
EXCAVATOR CITY OF LAUREL
DATE EXCAVATED September 13, 1993
DATE AUGERED September 14, 1993

TEST PIT

93G-1

LITHOLOGY



BGS – Below Ground Surface
All dimensions in Feet Below Ground Surface

▽ Top of Water Bearing Zone
TD – Total Depth

GEO
RESEARCH

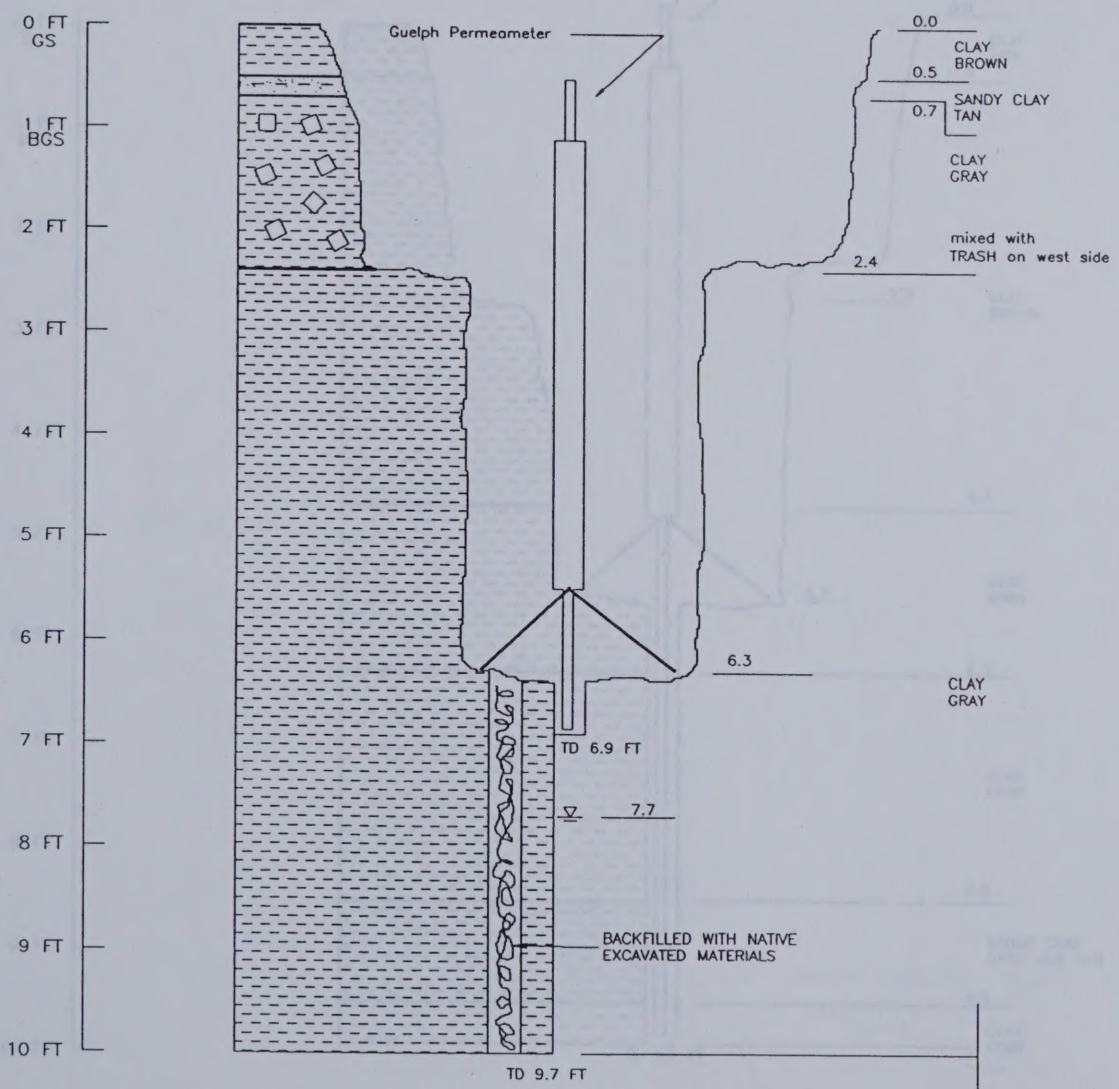
LITHOLOGIC LOG OF GUELPH BORING

PROJECT NUMBER 112035
SITE LAUREL LANDFILL
LOCATION NW S33 T1S R24E
YELLOWSTONE COUNTY, MT
EAST SIDE OF LANDFILL

SUPERVISOR M. M. HOFACKER
GEORESEARCH, INC
EXCAVATOR CITY OF LAUREL
DATE EXCAVATED September 13, 1993
DATE AUGERED September 22, 1993

TEST PIT
93G-2

LITHOLOGY



NOTE: SHALLOW BORING APPROXIMATELY 2 FEET FROM DEEP BORING

BGS – Below Ground Surface
All dimensions in Feet Below Ground Surface
∇ Top of Water Bearing Zone
TD – Total Depth

GEO
RESEARCH

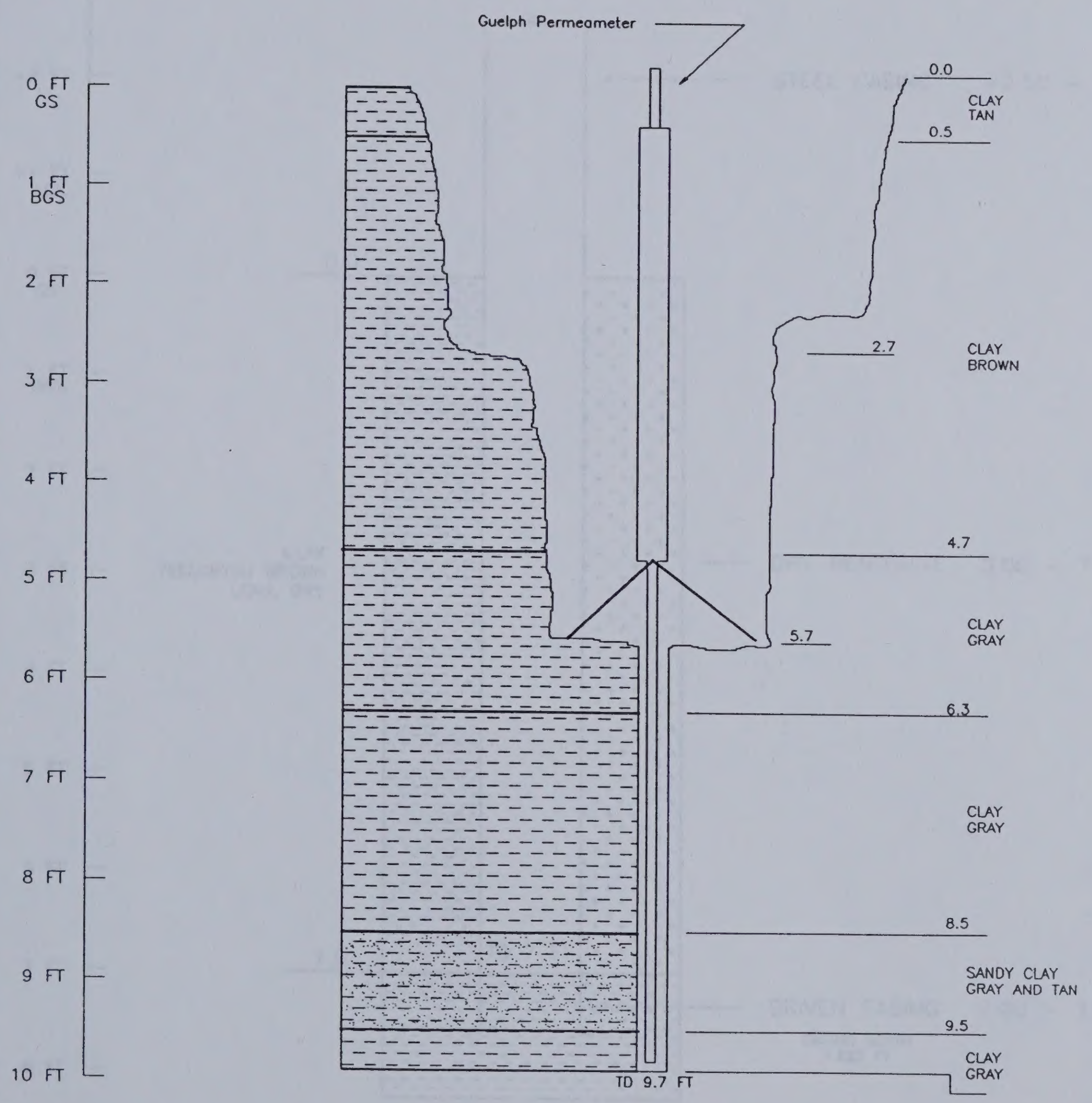
LITHOLOGIC LOG OF GUELPH BORING

PROJECT NUMBER 112035
SITE LAUREL LANDFILL
LOCATION NW S33 T1S R24E
YELLOWSTONE COUNTY, MT
WEST SIDE OF LANDFILL

SUPERVISOR M. M. HOFACKER
GEORESEARCH, INC
EXCAVATOR CITY OF LAUREL
DATE EXCAVATED September 13, 1993
DATE AUGERED September 14, 1993

TEST PIT
93G-3

LITHOLOGY



BGS – Below Ground Surface
All dimensions in Feet Below Ground Surface

∇ Top of Water Bearing Zone
TD – Total Depth

GEO
RESEARCH

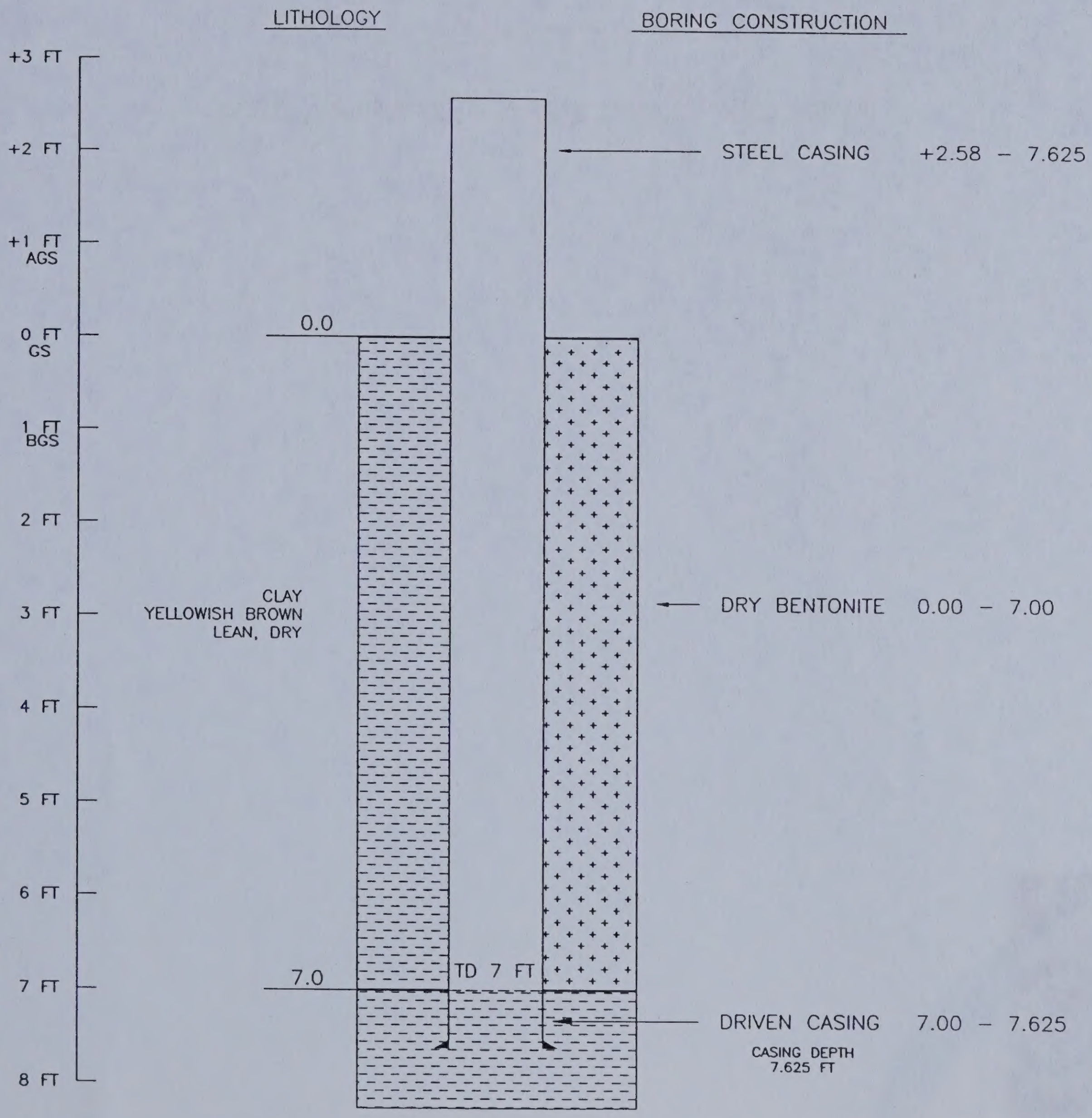
SINGLE RING INFILTROMETER LITHOLOGY AND CONSTRUCTION LOG

PROJECT NUMBER 112035
SITE LAUREL LANDFILL
LOCATION NW S33 T1S R24E
YELLOWSTONE COUNTY, MT
SOUTHEAST CORNER OF LANDFILL

SUPERVISOR CURT COOVER
GEORESEARCH, INC

DRILLER ADT PRO PUMP
DATE DRILLED October 28, 1992

BORING
R-1



AGS – Above Ground Surface
BGS – Below Ground Surface
All dimensions in Feet Below Ground Surface

▽ Top of Water Bearing Zone
TD – Total Depth

GEO
RESEARCH

APPENDIX C

SOIL ANALYSIS LABORATORY REPORTS

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: Curt Coover
ADDRESS: GeoResearch, Inc.
P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-50499
DATE: 12/10/92 da

SOIL ANALYSIS

112035 Laurel Landfill
Sampled 10/27/92
Submitted 12/03/92
Analyzed 12/09/92

pH	7.8	s.u.
Total Organic Carbon	0.5	% by weight

Chen-Northern, Inc.

A member of the HIH group of companies

1610 B STREET
P. O. BOX 4699
HELENA, MT 59604
(406) 443-5210
FAX (406) 449-3729

TECHNICAL REPORT

AMERICAN COUNCIL OF INDEPENDENT LABORATORIES, INC.

REPORT TO: GEO Research
Attn: Ms. Sally Staley
P.O. Box 5597
Helena, MT 59604

DATE: December 8, 1992
JOB NUMBER: 89-90
SHEET: 1 **OF** 1
INVOICE NO.: 127396

REPORT OF: Laboratory Analysis of Soil for Laurel Landfill; Project No. 112035

SAMPLE IDENTIFICATION:

On December 2, 1992 your personnel delivered to our laboratory one soil sample reported to be from the above referenced project. At your request, we performed particle size analysis and moisture content tests in accordance with ASTM D422 and D1140 and D2216, respectively.

The test results are summarized as follows:

TEST RESULTS

SIEVE ANALYSIS	Sample: R-1; 6'-7' Lab No. 11483
Sieve Size	PERCENT PASSING
No. 4	100
No. 10	100
No. 20	99
No. 40	98
No. 80	96
No. 200	92
HYDROMETER ANALYSIS	
0.05 mm	*
0.037 mm	*
0.0225 mm	79
0.019 mm	76
0.012 mm	70
0.009 mm	67
0.005 mm	59
0.002 mm	33
MOSISTURE CONTENT	
As Received, %	16.0

* The soil/slurry did not register on the hydrometer scale, no readings were obtained

Reviewed By: Jeremiah B. Bowser

Distribution:

AS A MUTUAL PROTECTION TO CLIENTS, THE PUBLIC AND OURSELVES, ALL REPORTS ARE SUBMITTED AS THE CONFIDENTIAL PROPERTY OF OUR CLIENTS AND AUTHORIZATION FOR

Chen-Northern, Inc.

GRAIN SIZE DISTRIBUTION CURVE

Project: Geo Research

Location: L-2

Classification Lean CLAY

Moisture Content ______ %

Liquid Limit 43 %

Sample No. 1001

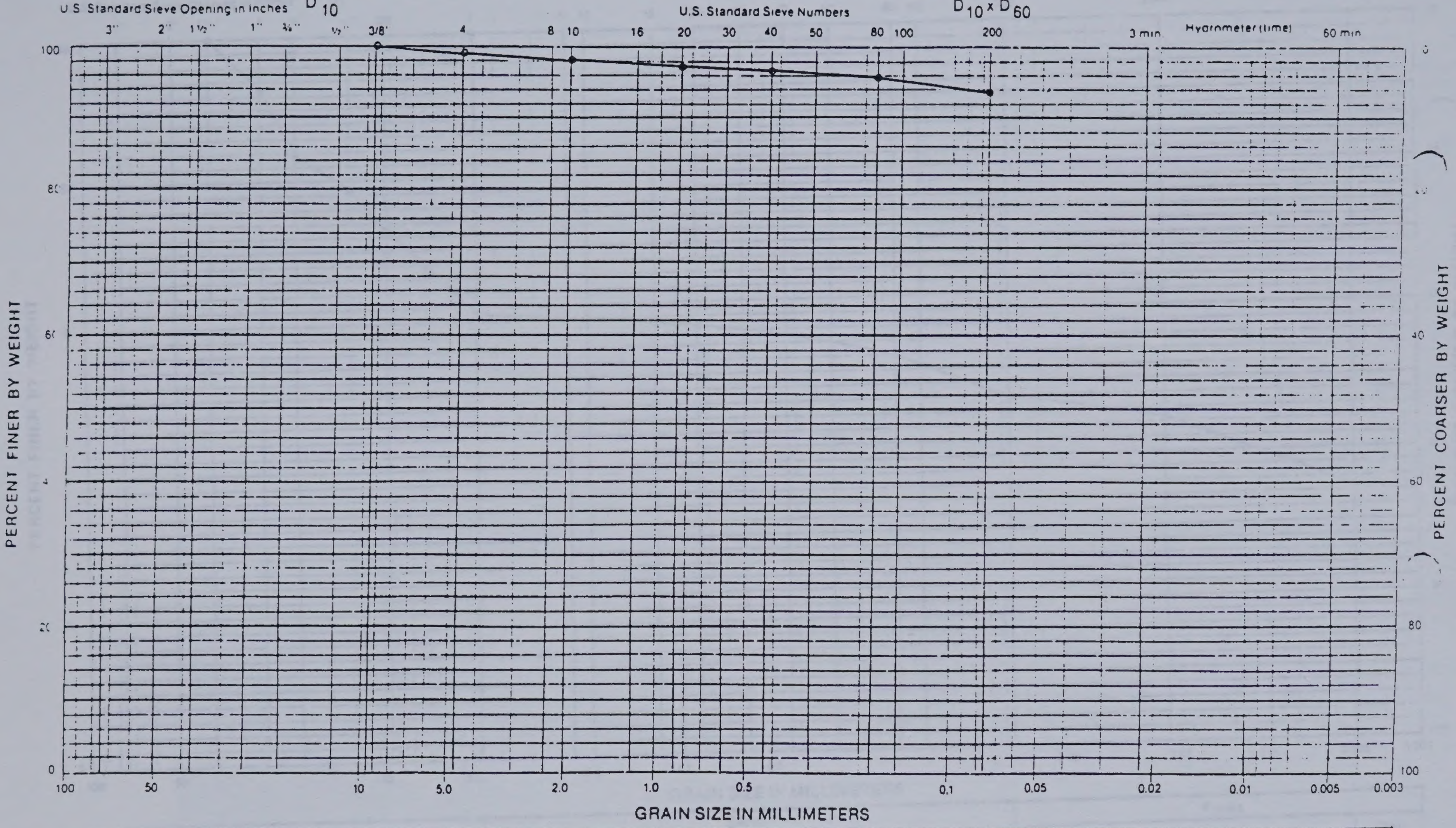
Job No. 91-627

Date March, 1992

Plasticity Index 24 %

Coefficient of Uniformity $= C_U = \frac{D_{60}}{D_{10}} =$ N/A

Coefficient of Curvature $= C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}} =$ N/A



Gravel		Sand			Fines	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

(Rev. 1/89) CNI-105

GRAIN SIZE DISTRIBUTION CURVE

Project: Geo Research

Location: L-1

Classification Clayey GRAVEL

Moisture Content ______ %

Sample No. 1000

Job No. 91-627

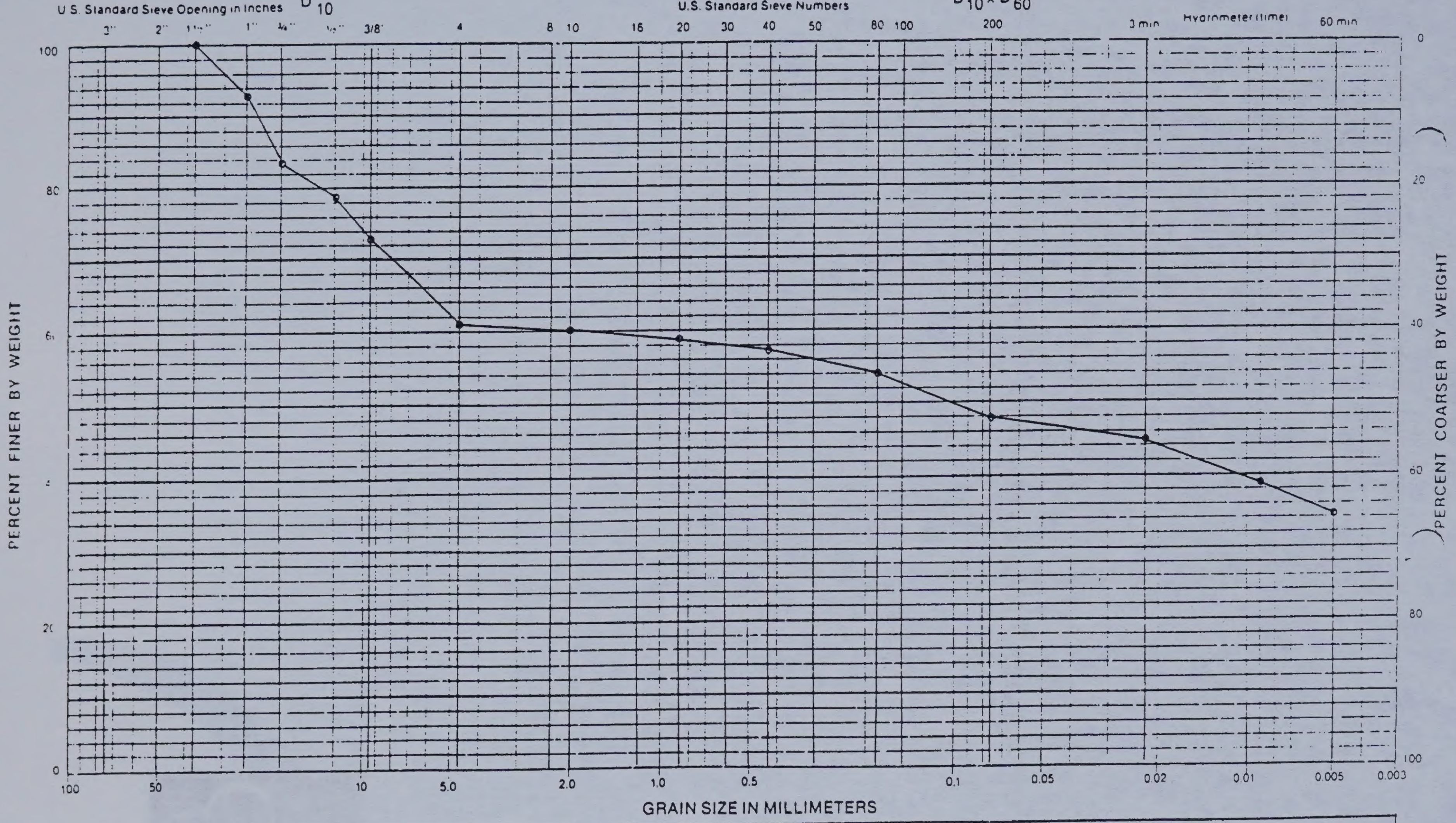
Date March, 1992

Liquid Limit 53 %

Plasticity Index 23 %

Coefficient of Uniformity $= C_U = \frac{D_{60}}{D_{10}} =$ N/A

Coefficient of Curvature $= C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}} =$ N/A

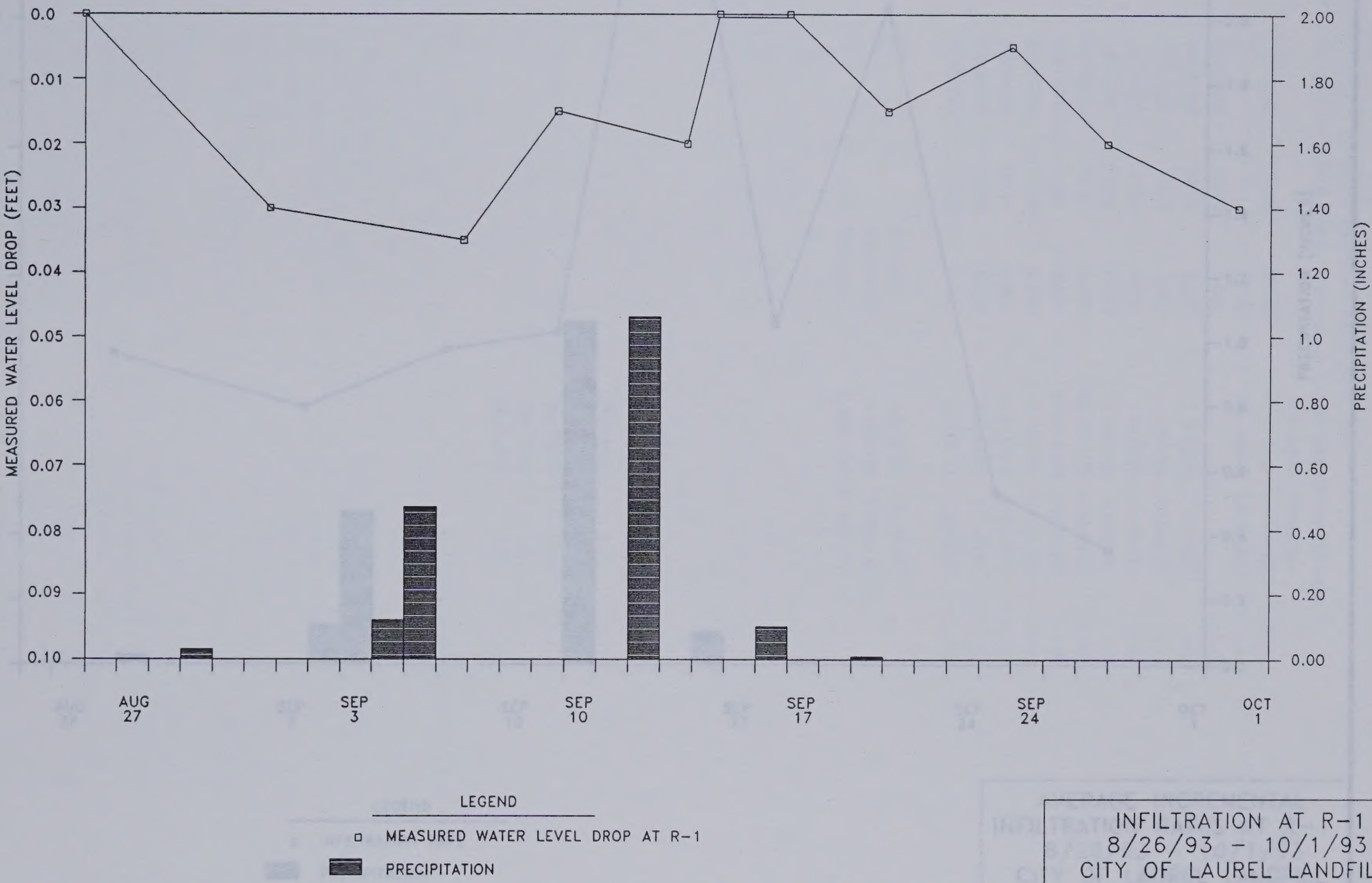


Gravel		Sand			Fines	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

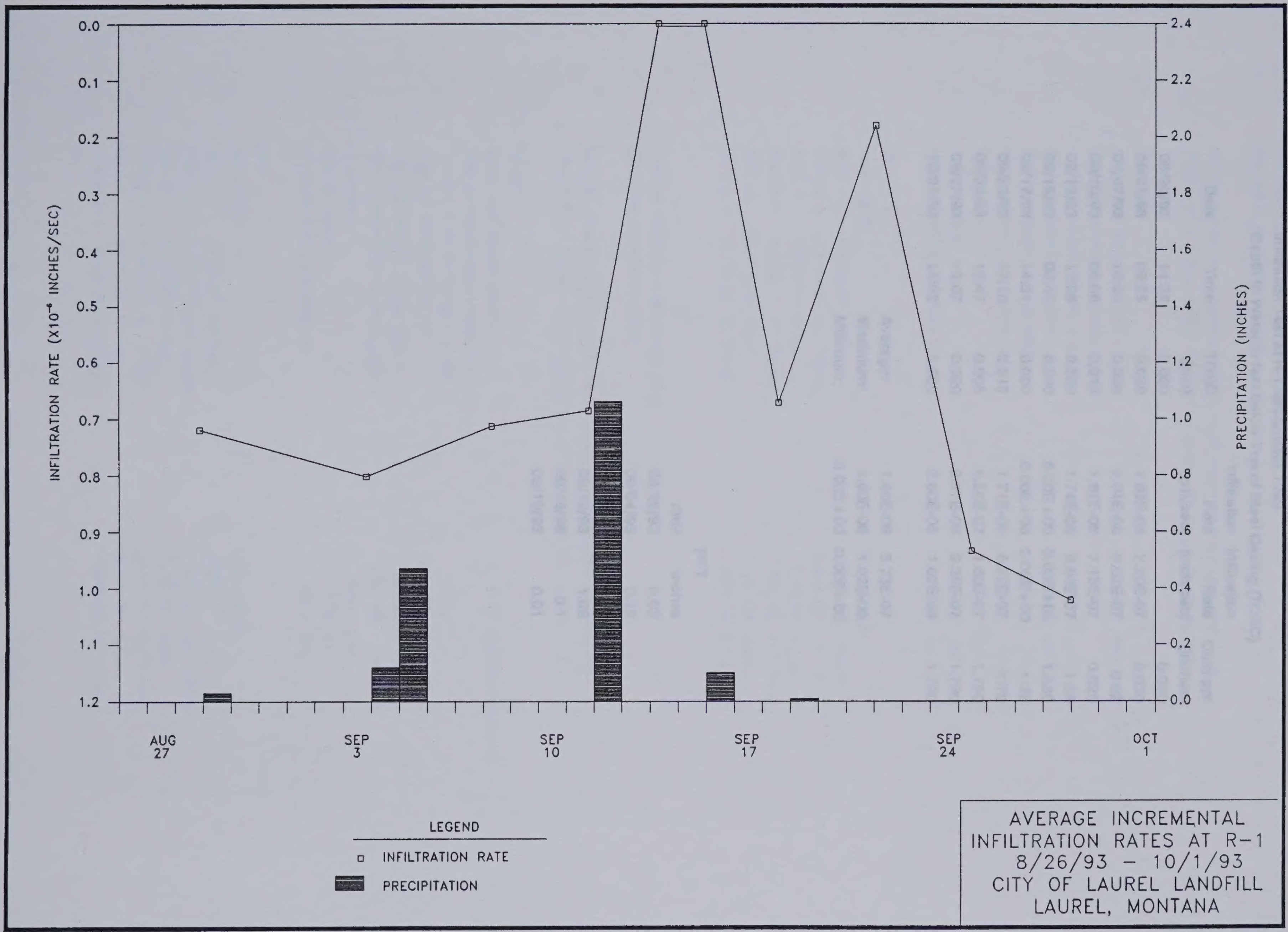
(Rev. 1/89) CNI-105

APPENDIX D

VADOSE ZONE AND AQUIFER TESTING DATA AND CALCULATIONS



INFILTRATION AT R-1
8/26/93 - 10/1/93
CITY OF LAUREL LANDFILL
LAUREL, MONTANA



AVERAGE INCREMENTAL INFILTRATION RATES AT R–1
8/26/93 – 10/1/93
CITY OF LAUREL LANDFILL
LAUREL, MONTANA

Infiltration Test at R-1 September 1993

Depth to Water in feet below Top of Steel Casing (TOSC)

Date	Time	TOSC (feet)	Infiltration Rate (cm/sec)	Infiltration Rate (inch/sec)	Cum ppt (inches)
08/26/93	14:28	0.000			0.000
09/01/93	09:25	0.030	1.83E-06	7.20E-07	0.030
09/07/93	10:50	0.035	2.04E-06	8.02E-07	0.62
09/10/93	08:56	0.015	1.81E-06	7.13E-07	0.620
09/14/93	10:08	0.020	1.74E-06	6.86E-07	1.68
09/15/93	09:45	0.000	0.00E+00	0.00E+00	1.680
09/17/93	14:51	0.000	0.00E+00	0.00E+00	1.78
09/20/93	17:16	0.015	1.71E-06	6.72E-07	1.79
09/24/93	13:47	0.005	4.58E-07	1.80E-07	1.790
09/27/93	13:07	0.020	2.37E-06	9.35E-07	1.790
10/01/93	14:58	0.030	2.60E-06	1.02E-06	1.790
		Average:	1.46E-06	5.73E-07	
		Maximum:	2.60E-06	1.02E-06	
		Minimum:	0.00E+00	0.00E+00	

PPT

date	inches
08/29/93	0.03
09/04/93	0.12
09/05/93	0.47
09/12/93	1.06
09/16/93	0.1
09/19/93	0.01

Ponded Infiltration from Single Ring
Reynolds and Elrick (1990)

K(fs) (cm/sec) = alpha*G(e)*A*R/(a*(alpha*H+1)+G(e)*alpha*Pi*a^2)
Phi(m) (cm^2/sec) =G(e)*A*R/(a*(alpha*H+1)+G(e)*alpha*Pi*a^2)

Where:
alpha (soil texture factor) = 0.025 for clay
G(e) (dimensionless shape factor) =
G(e) = 0.316 * (d/a) + 0.184 0.974
A (cross sectional area) = 182.4147 cm^2
R(a) (cm/sec) (Average rate) = 1.46E-06 cm/sec
R(m) (cm/sec) (Maximum rate) = 2.6E-06 cm/sec
H (head) = 292.1 cm
a (well radius) = 7.62 cm
d (depth of ring insertion) = 19.05 cm

R-1

Average R			Maximum R	
K(fs) =	9.55E-08	cm/sec	1.70E-07	cm/sec
Phi(m) =	3.82E-06	cm^2/sec	6.81E-06	cm^2/sec
K(fs) =	3.76E-08	in/sec	6.7E-08	in/sec
Phi(m) =	5.92E-07	in^2/sec	1.06E-06	in^2/sec
K(fs) =	3.13E-09	ft/sec	5.59E-09	ft/sec
Phi(m) =	4.11E-09	ft^2/sec	7.33E-09	ft^2/sec

Ponded Infiltration from Single Ring
Reynolds and Elrick (1990)

K(fs) (cm/sec) = alpha*G(e)*A*R/(a*(alpha*H+1)+G(e)*alpha*Pi*a^2)
Phi(m) (cm^2/sec) =G(e)*A*R/(a*(alpha*H+1)+G(e)*alpha*Pi*a^2)

Where:
alpha (soil texture factor) = 0.12 for structured clay
G(e) (dimensionless shape factor) =
G(e) = 0.316 * (d/a) + 0.184 0.974
A (cross sectional area) = 182.4147 cm^2
R(a) (cm/sec) (Average rate) = 1.46E-06 cm/sec
R(m) (cm/sec) (Maximum rate) = 2.6E-06 cm/sec
H (head) = 292.1 cm
a (well radius) = 7.62 cm
d (depth of ring insertion) = 19.05 cm

R-1

Average R			Maximum R	
K(fs) =	1.05E-07	cm/sec	1.87E-07	cm/sec
Phi(m) =	8.73E-07	cm^2/sec	1.56E-06	cm^2/sec
K(fs) =	4.13E-08	in/sec	7.36E-08	in/sec
Phi(m) =	1.35E-07	in^2/sec	2.41E-07	in^2/sec
K(fs) =	3.44E-09	ft/sec	6.13E-09	ft/sec
Phi(m) =	9.4E-10	ft^2/sec	1.68E-09	ft^2/sec

Raw Data

93G-1 09/20/93 H = 5 cm A = 2.13 cm^2

Time (min)	Delta Time	Level (cm)	Water Level	Rate (cm/min)
1425		6.2		
1459	34	6.85	0.65	0.019
1539	40	7.44	0.59	0.015
1600	21	7.8	0.36	0.017
1610	10	8	0.2	0.020
1620	10	8.2	0.2	0.020
1630	10	8.35	0.15	0.015
1640	10	8.55	0.2	0.020
1650	10	8.7	0.15	0.015
Average Rate =				0.018

93G-1 09/21/93 H = 10 A = 2.13 cm^2

Time (min)	Delta Time	Water Level (cm)	Delta Water Level	Infiltration Rate (cm/min)
1802		27.7		
1850	48	43.9	16.2	0.338
1913	23	52.1	8.2	0.357
1936	23	60.6	8.5	0.370
2004	28	70	9.4	0.336
Average Rate =				0.350

93G-1 09/15/93 H = 5 cm A = 2.13 cm^2

Time (min)	Delta Time	Water Level (cm)	Delta Water Level	Infiltration Rate (cm/min)
1244		20.5		
1310	26	21.2	0.7	0.027
1336	26	21.8	0.6	0.023
1402	26	22.5	0.7	0.027
1428	26	23.3	0.8	0.031
1455	27	24	0.7	0.026
1538	43	25.25	1.25	0.029
Average Rate =				0.027

Raw Data

93G-2 09/22/93 H = 5 cm A = 2.13 cm^2

	Time (min)	Delta Time	Water Level (cm)	Delta Water Level	Infiltration Rate (cm/min)
	1157		1.1		
	1239	42	1.63	0.53	0.013
tr ct re cla	1242	3	2.75	1.12	0.373
tr ct re cla	1316	34	8.2	5.45	0.160
	1322	6	9	0.8	0.133
	1335	13	12.1	3.1	0.238
	1349	14	16.1	4	0.286
	1408	19	21.9	5.8	0.305
	1413	5	23.9	2	0.400
	1428	15	29.9	6	0.400
	1435	7	33.1	3.2	0.457
	1440	5	35	1.9	0.380
	Average Rate =				0.409

93G-2 09/22/93 H = 10 cm A = 2.13 cm^2

Time (min)	Delta Time	Water Level (cm)	Delta Water Level	Infiltration Rate (cm/min)
1441		7.4		
1456	15	7.7	0.3	0.020
1501	5	14.3	6.6	1.320
1511	10	28.8	14.5	1.450
1516	5	36.7	7.9	1.580
1522	6	46.7	10	1.667
1527	5	55.3	8.6	1.720
1529	2	58.8	3.5	1.750
1531	2	62.1	3.3	1.650
1533	2	65.8	3.7	1.850
1535	2	69.5	3.7	1.850
1537	2	73.2	3.7	1.850
Average Rate =				1.850

93G-2 09/16/93 H = 5 cm A = 2.13 cm^2

Time (min)	Delta Time	Water Level (cm)	Delta Water Level	Infiltration Rate (cm/min)
1231		3.6		
1234	3	4.9	1.3	0.433
1240	6	7.3	2.4	0.400
1245	5	9.8	2.5	0.500
1248	3	11.15	1.35	0.450
1251	3	12.5	1.35	0.450
1254	3	13.8	1.3	0.433
1256	2	14.7	0.9	0.450
1258	2	15.5	0.8	0.400
Average Rate =				0.440

Raw Data

	93G-3	09/15/93	H = 5 cm		A = 2.13 cm^2
	Time (min)	Delta Time	Water Level (cm)	Delta Water Level	Infiltration Rate (cm/min)
	1729		0.9		
	1751	22	0.9	0	0.000
	1850	59	1.3	0.4	0.007
tr ct re cla	1939	49	3.9	2.6	0.053
tr ct re cla	2012	33	8	4.1	0.124
	2020	8	9.4	1.4	0.175
	2031	11	10.7	1.3	0.118
	2045	14	12.6	1.9	0.136
	2059	14	14.1	1.5	0.107
	Average Rate =				0.120

93G-3	09/20/93	H = 10 cm		A = 2.13 cm^2
Time (min)	Delta Time	Water Level (cm)	Delta Water Level	Infiltration Rate (cm/min)
1145		3.8		
1147	2	4.8	1	0.500
1152	5	7.1	2.3	0.460
1158	6	9.8	2.7	0.450
1206	8	12.8	3	0.375
1210	4	14.4	1.6	0.400
1215	5	16.45	2.05	0.410
1220	5	18.4	1.95	0.390
1224	4	19.95	1.55	0.388
1228	4	21.4	1.45	0.362
1232	4	22.9	1.5	0.375
1237	5	24.7	1.8	0.360
1239	2	25.43	0.73	0.365
1243	4	27	1.57	0.393
1247	4	28.43	1.43	0.357
1251	4	29.83	1.4	0.350
1256	5	31.6	1.77	0.354
1301	5	33.26	1.66	0.332
1306	5	34.9	1.64	0.328
1308	2	35.53	0.63	0.315
1310	2	36.16	0.63	0.315
Average Rate =				0.319

Raw Data

93G-3 09/20/93 H = 5 cm A = 2.13 cm^2

Time (min)	Delta Time	Water Level (cm)	Delta Water Level	Infiltration Rate (cm/min)
1116		2.2		
1118	2	3.2	1	0.500
1120	2	4.15	0.95	0.475
1122	2	5.2	1.05	0.525
1124	2	6.1	0.9	0.450
1126	2	7.1	1	0.500
1128	2	8.1	1	0.500
1131	3	9.7	1.6	0.533
1133	2	10.9	1.2	0.600
1135	2	12	1.1	0.550
1137	2	13	1	0.500
1139	2	14.1	1.1	0.550
1141	2	15.2	1.1	0.550
1143	2	16.3	1.1	0.550
Average Rate =				0.550

Raw Data

93G-3 09/16/93 H = 10 cm A = 2.13 cm^2

Time (min)	Delta Time	Water Level (cm)	Delta Water Level	Infiltration Rate (cm/min)
2104		5.6		
2134	30	9.1	3.5	0.117
2212	38	31.5	22.4	0.589
2226	14	43.2	11.7	0.836
2227	1	8.5	adjusted H2O	
2333	66	65.6	57.1	0.865
2334	1	13.5	adjusted H2O	
9	35	49	35.5	1.014
15	6	16.9	adjusted H2O	
50	35	59	42.1	1.203
52	2	20.9	adjusted H2O	
110	18	31.5	10.6	0.589
120	10	49.8	18.3	1.830
130	10	69.2	19.4	1.940
133	3	75	5.8	1.933
133		26	adjusted H2O	
140	7	26.5	0.5	0.071
150	10	32	5.5	0.550
200	10	52.2	20.2	2.020
214		31.5	adjusted H2O	
220	6	32.3	0.8	0.133
227	7	32.4	0.1	0.014
237	10	51.5	19.1	1.910
245	8	69	17.5	2.188
245		35.4	adjusted H2O	
252	7	36	0.6	0.086
258	6	41.5	5.5	0.917
305	7	58.5	17	2.429
308	3	65.4	6.9	2.300
312	4	75.5	10.1	2.525
Average Rate =				?????

Single Head Richards Analysis
Elrick, Reynolds, and Tan (1989)

K(fs) (cm/sec) = C*A*R/[2*Pi*H^2+C*Pi*a^2+(2*Pi*H/alpha)]
Phi(m) (cm^2/sec) = C*A*R/[(2*Pi*H^2+C*Pi*a^2)*alpha+2*Pi*H]

Where:
C (shape factor at H = 5 cm) = 0.82 average for structured & unstructured clay
C (shape factor at H = 10 cm) = 1.23 average for structured & unstructured clay
A (reservoir constant) = 2.13 cm^2
R1 (cm/sec) = Average rate (cm/min) / 60 sec/min (for 5 cm head)
R2 (cm/sec) = Average rate (cm/min) / 60 sec/min (for 10 cm head)
H1 (head) = 5 cm
H2 (head) = 10 cm
a (well radius) = 3 cm
alpha (soil texture factor) = 0.025 for clay

93G-1
R1 = 0.000300 cm/sec (for H = 5 cm)
Single Head K(fs) = 3.65E-07 cm/sec
Single Head Phi(m) = 1.46E-05 cm^2/sec
2nd R1 = 0.000450 cm/sec (for H = 5 cm)
Single Head K(fs) = 5.47E-07 cm/sec
Single Head Phi(m) = 2.19E-05 cm^2/sec
R2 = 0.005833 cm/sec (for H = 10 cm)
Single Head K(fs) = 4.81E-06 cm/sec
Single Head Phi(m) = 1.92E-04 cm^2/sec

93G-2
R1 = 0.006817 cm/sec (for H = 5 cm)
Single Head K(fs) = 8.29E-06 cm/sec
Single Head Phi(m) = 3.31E-04 cm^2/sec
2nd R1 = 0.007333 cm/sec (for H = 5 cm)
Single Head K(fs) = 8.91E-06 cm/sec
Single Head Phi(m) = 3.57E-04 cm^2/sec
R2 = 0.030833 cm/sec (for H = 10 cm)
Single Head K(fs) = 2.54E-05 cm/sec
Single Head Phi(m) = 1.02E-03 cm^2/sec

93G-3
R1 = 0.002000 cm/sec (for H = 5 cm)
Single Head K(fs) = 1.11E-05 cm/sec
Single Head Phi(m) = 4.46E-04 cm^2/sec
2nd R1 = 0.009167 cm/sec (for H = 5 cm)
Single Head K(fs) = 2.43E-06 cm/sec
Single Head Phi(m) = 9.72E-05 cm^2/sec
R2 = 0.005317 cm/sec (for H = 5 cm)
Single Head K(fs) = 4.39E-06 cm/sec
Single Head Phi(m) = 1.75E-04 cm^2/sec

Single Head Richards Analysis
Elrick, Reynolds, and Tan (1989)

K(fs) (cm/sec) = C*A*R/[2*Pi*H^2+C*Pi*a^2+(2*Pi*H/alpha)]
Phi(m) (cm^2/sec) = C*A*R/[(2*Pi*H^2+C*Pi*a^2)*alpha+2*Pi*H]

Where:
C (shape factor at H = 5 cm) = 0.82 average for structured & unstructured clay
C (shape factor at H = 10 cm) = 1.23 average for structured & unstructured clay
A (reservoir constant) = 2.13 cm^2
R1 (cm/sec) = Average rate (cm/min) / 60 sec/min (for 5 cm head)
R2 (cm/sec) = Average rate (cm/min) / 60 sec/min (for 10 cm head)
H1 (head) = 5 cm
H2 (head) = 10 cm
a (well radius) = 3 cm
alpha (soil texture factor) = 0.12 for structured clay

93G-1
R1 = 0.000300 cm/sec (for H = 5 cm)
Single Head K(fs) = 1.19E-06 cm/sec
Single Head Phi(m) = 9.88E-06 cm^2/sec
2nd R1 = 0.000450 cm/sec (for H = 5 cm)
Single Head K(fs) = 1.78E-06 cm/sec
Single Head Phi(m) = 1.48E-05 cm^2/sec
R2 = 0.005833 cm/sec (for H = 10 cm)
Single Head K(fs) = 1.29E-05 cm/sec
Single Head Phi(m) = 1.07E-04 cm^2/sec

93G-2
R1 = 0.006817 cm/sec (for H = 5 cm)
Single Head K(fs) = 2.69E-05 cm/sec
Single Head Phi(m) = 2.24E-04 cm^2/sec
2nd R1 = 0.007333 cm/sec (for H = 5 cm)
Single Head K(fs) = 2.90E-05 cm/sec
Single Head Phi(m) = 2.41E-04 cm^2/sec
R2 = 0.030833 cm/sec (for H = 10 cm)
Single Head K(fs) = 6.81E-05 cm/sec
Single Head Phi(m) = 5.67E-04 cm^2/sec

93G-3
R1 = 0.002000 cm/sec (for H = 5 cm)
Single Head K(fs) = 1.65E-06 cm/sec
Single Head Phi(m) = 6.60E-05 cm^2/sec
2nd R1 = 0.009167 cm/sec (for H = 5 cm)
Single Head K(fs) = 7.56E-06 cm/sec
Single Head Phi(m) = 3.02E-04 cm^2/sec
R2 = 0.005317 cm/sec (for H = 5 cm)
Single Head K(fs) = 1.17E-05 cm/sec
Single Head Phi(m) = 9.78E-05 cm^2/sec

Laplace and Gardner Analyses
Reynolds and Elrick (1985)

Laplace: K(fs) (cm/sec) = C*A*R/[2*Pi*H^2+C*Pi*a^2]
Gardner: Phi(m) (cm^2/sec) = C*A*R/[2*Pi*H]

Where:
C (shape factor at H = 5 cm) = 0.82 average for structured & unstructured clay
C (shape factor at H = 10 cm) = 1.23 average for structured & unstructured clay
A (reservoir constant) = 2.13 cm^2
R1 (cm/sec) = Average rate (cm/min) / 60 sec/min (for 5 cm head)
R2 (cm/sec) = Average rate (cm/min) / 60 sec/min (for 10 cm head)
H1 (head) = 5 cm
H2 (head) = 10 cm
a (well radius) = 3 cm

93G-1
R1 = 0.000300 cm/sec (for H = 5 cm)
Laplace K(fs) = 2.91E-06 cm/sec
Gardner Phi(m) = 1.67E-05 cm^2/sec
2nd R1 = 0.000450 cm/sec (for H = 5 cm)
Laplace K(fs) = 4.36E-06 cm/sec
Gardner Phi(m) = 2.50E-05 cm^2/sec
R2 = 0.005833 cm/sec (for H = 10 cm)
Laplace K(fs) = 2.35E-05 cm/sec
Gardner Phi(m) = 2.43E-04 cm^2/sec

93G-2
R1 = 0.006817 cm/sec (for H = 5 cm)
Laplace K(fs) = 6.60E-05 cm/sec
Gardner Phi(m) = 3.79E-04 cm^2/sec
2nd R1 = 0.007333 cm/sec (for H = 5 cm)
Laplace K(fs) = 7.11E-05 cm/sec
Gardner Phi(m) = 4.08E-04 cm^2/sec
R2 = 0.030833 cm/sec (for H = 10 cm)
Laplace K(fs) = 1.24E-04 cm/sec
Gardner Phi(m) = 1.29E-03 cm^2/sec

93G-3
R1 = 0.002000 cm/sec (for H = 5 cm)
Laplace K(fs) = 1.94E-05 cm/sec
Gardner Phi(m) = 1.11E-04 cm^2/sec
2nd R1 = 0.009167 cm/sec (for H = 5 cm)
Laplace K(fs) = 8.88E-05 cm/sec
Gardner Phi(m) = 5.10E-04 cm^2/sec
R2 = 0.005317 cm/sec (for H = 5 cm)
Laplace K(fs) = 2.14E-05 cm/sec
Gardner Phi(m) = 2.22E-04 cm^2/sec

AVERAGE GUELPH PERMEAMETER TEST RESULTS

a=0.12						
Single Head K(fs) =	1.79E-05	cm/sec	7.03E-06	in/sec	5.86E-07	ft/sec
Single Head Phi(m) =	1.81E-04	cm^2/sec	2.81E-05	in^2/sec	1.95E-07	ft^2/sec
a=0.025						
Single Head K(fs) =	7.37E-06	cm/sec	2.90E-06	in/sec	2.42E-07	ft/sec
Single Head Phi(m) =	2.95E-04	cm^2/sec	4.57E-05	in^2/sec	3.17E-07	ft^2/sec
Laplace						
Single Head K(fs) =	4.68E-05	cm/sec	1.84E-05	in/sec	1.54E-06	ft/sec
Gardner						
Single Head Phi(m) =	3.56E-04	cm^2/sec	5.51E-05	in^2/sec	3.83E-07	ft^2/sec

Two Head Richards Analysis
Soilmoisture Equipment Corp. (1986)

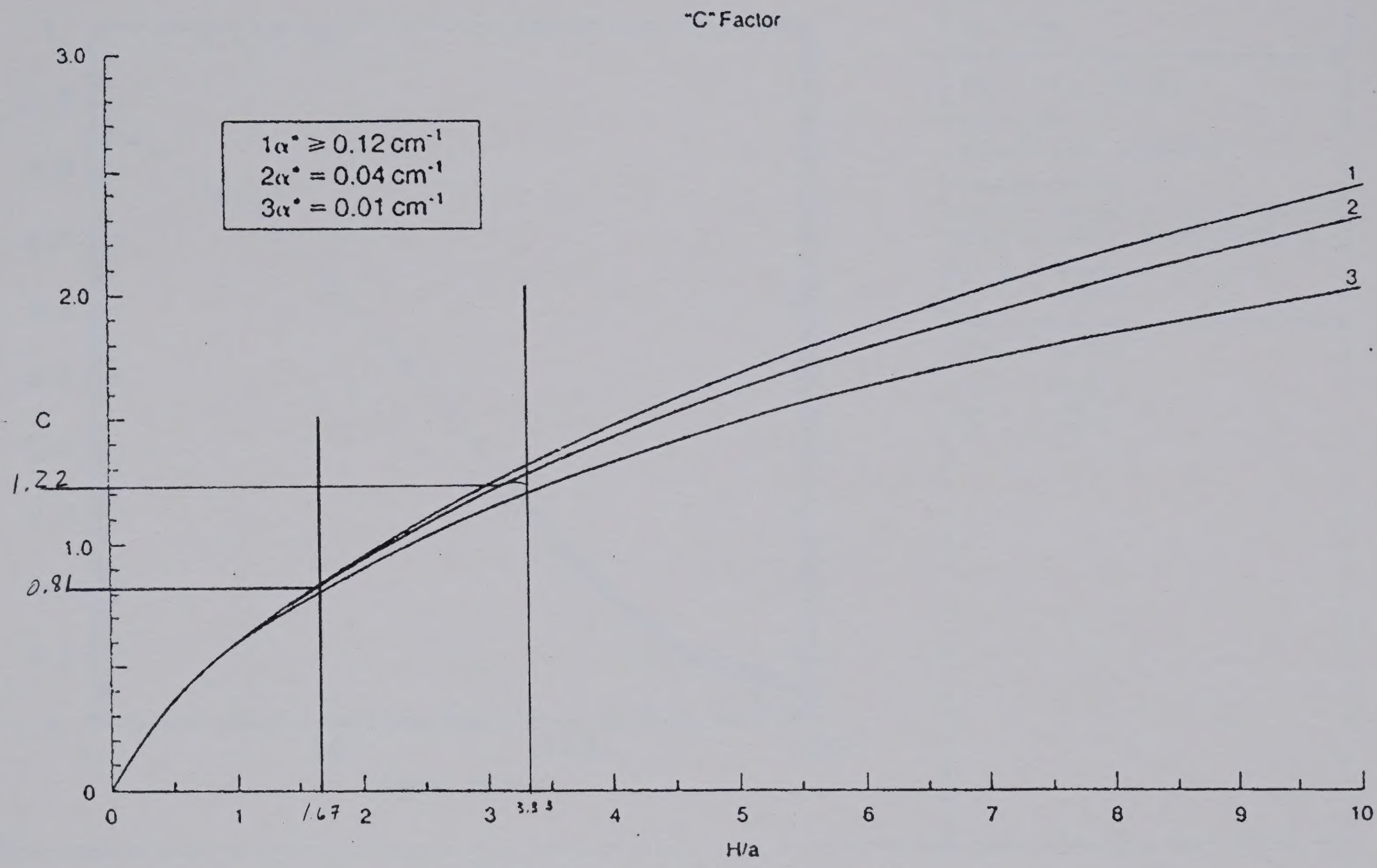
K(fs) (cm/sec) = [0.0041*A*R2] - [0.0054*A*R1]
Phi(m) (cm^2/sec) = [0.0572*A*R1]-[0.0237*A*R2]
Alpha = k(fs)/Phi(m)

where:
R1 (cm/sec) = Average rate (cm/min) / 60 sec/min (for 5 cm head)
R2 (cm/sec) = Average rate (cm/min) / 60 sec/min (for 10 cm head)
Inner Reservoir Constant = A = 2.13 cm^2

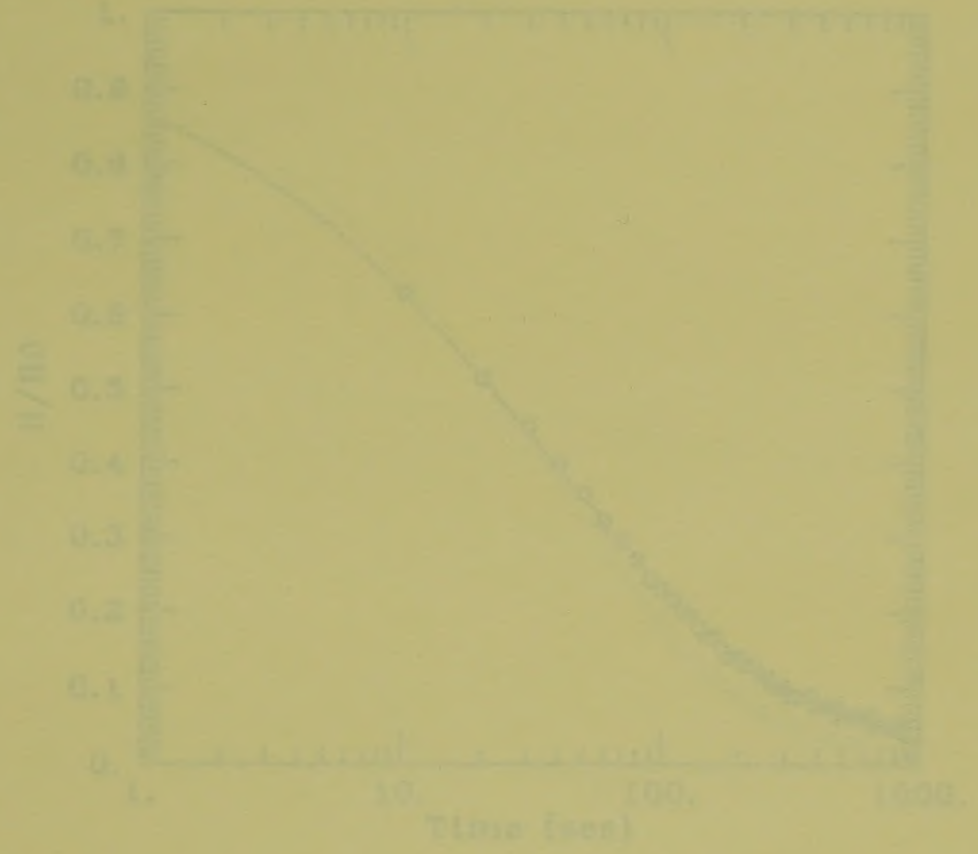
93G-1
R1 = 0.000300 cm/sec R1 (cm/min)= 0.018
R2 = 0.005833 cm/sec R2 (cm/min)= 0.350
K(fs) = 4.75E-05 cm/sec
Phi(m) = -2.58E-04 cm^2/sec
Alpha = -0.184133 cm^-1

93G-2
R1 = 0.006817 cm/sec R1 (cm/min)= 0.409
R2 = 0.030833 cm/sec R2 (cm/min)= 1.850
K(fs) = 1.91E-04 cm/sec
Phi(m) = -7.26E-04 cm^2/sec
Alpha = -0.262902 cm^-1

93G-3
R1 = 0.002000 cm/sec R1 (cm/min)= 0.120
R2 = 0.005317 cm/sec R2 (cm/min)= 0.319
K(fs) = 2.34E-05 cm/sec
Phi(m) = -2.47E-05 cm^2/sec
Alpha = -0.947724 cm^-1



GUELPH PERMEAMETER
SHAPE FACTOR "C"
SINGLE HEAD
RICHARDS ANALYSIS
ELRICK, REYNOLDS, & TAN (1989)



DATA SET:
[illegible]
[illegible]

AQUIFER TYPE:
Confined

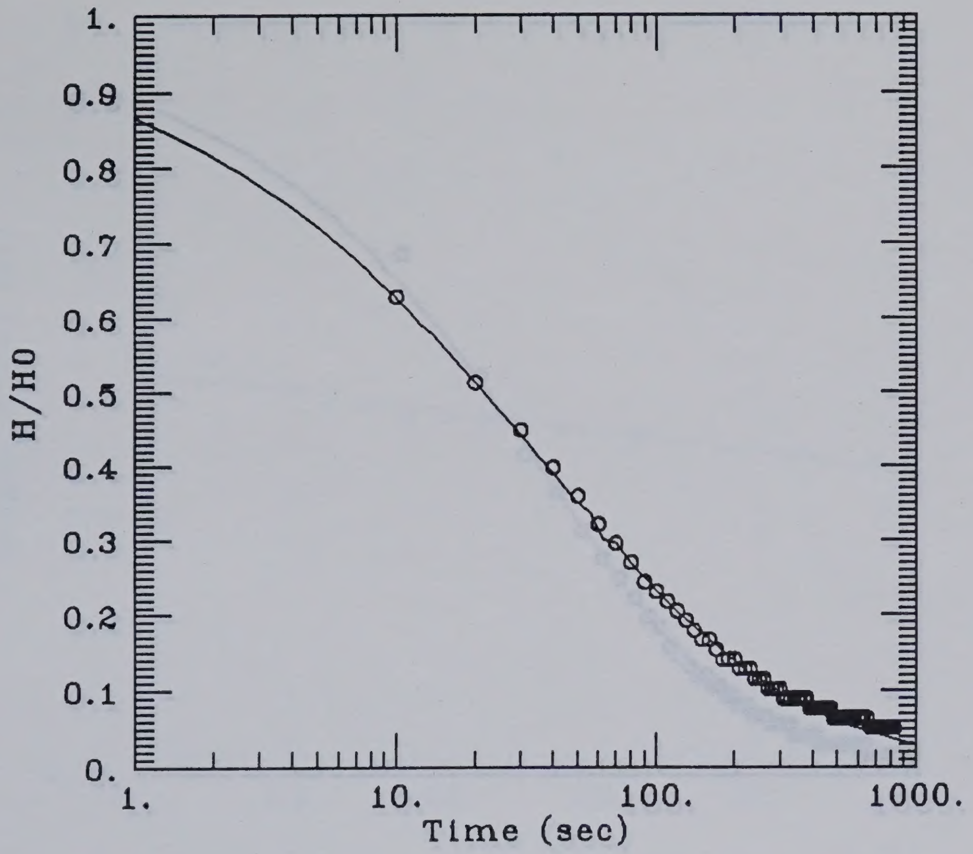
SOLUTION METHOD:
Cooper et al.

ESTIMATED PARAMETERS:
T = [illegible]
S = [illegible]

TEST DATA:
H0 = [illegible]
rc = [illegible]
rw = [illegible]

MW-1 Slug In

GeoResearch, Inc.	Client: City of Laurel
Project No. 112038	Location: Laurel Landfill



DATA SET:
lmw-1in.dat
12/29/92

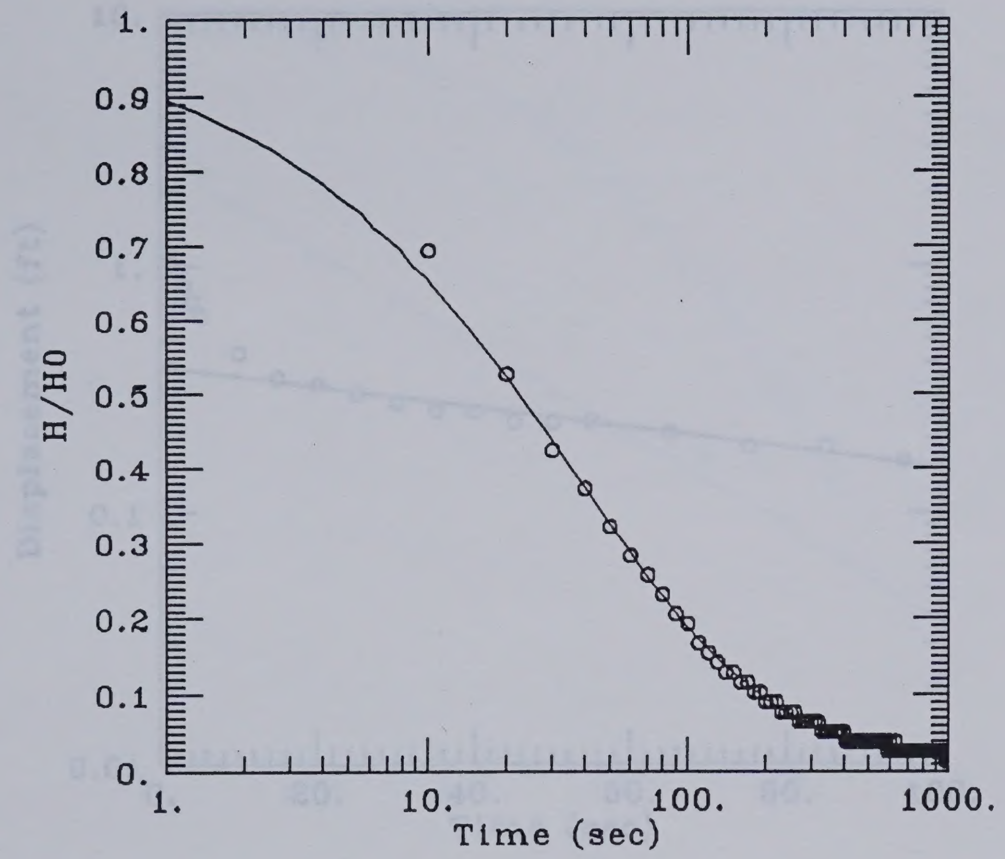
AQUIFER TYPE:
Confined
SOLUTION METHOD:
Cooper et al.

ESTIMATED PARAMETERS:
T = 6.0755E-05 ft^2/sec
S = 0.05021

TEST DATA:
H0 = 1.8 ft
rc = 0.08333 ft
rw = 0.25 ft

MW-1 Slug In

GeoResearch, Inc.	Client: **City of Laurel**
Project No.: **112035**	Location: **Laurel Landfill**



DATA SET:
lnv-1out.dat
12/29/92

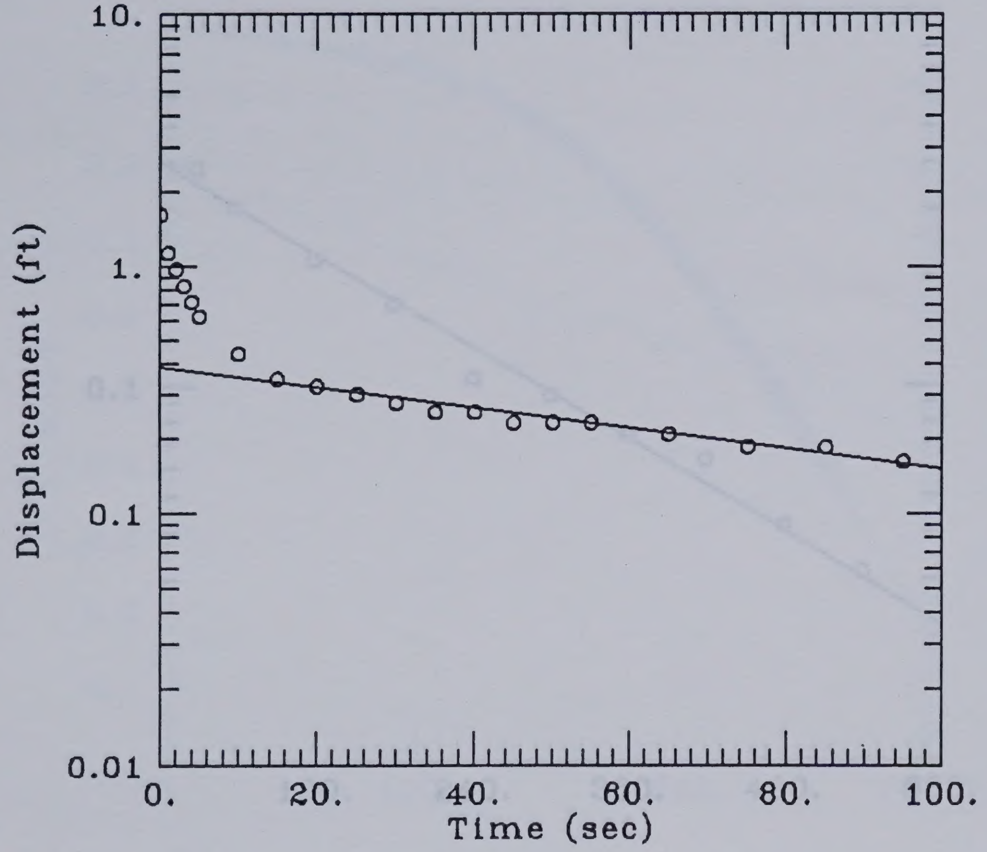
AQUIFER TYPE:
Confined
SOLUTION METHOD:
Cooper et al.

ESTIMATED PARAMETERS:
T = 0.0001305 ft^2/sec
S = 0.011

TEST DATA:
H0 = 1.8 ft
rc = 0.08333 ft
rw = 0.25 ft

MW-1 Slug Out

GeoResearch, Inc.	Client: **City of Laurel**
Project No.: **112035**	Location: **Laurel Landfill**



DATA SET:
12out.dat
12/29/92

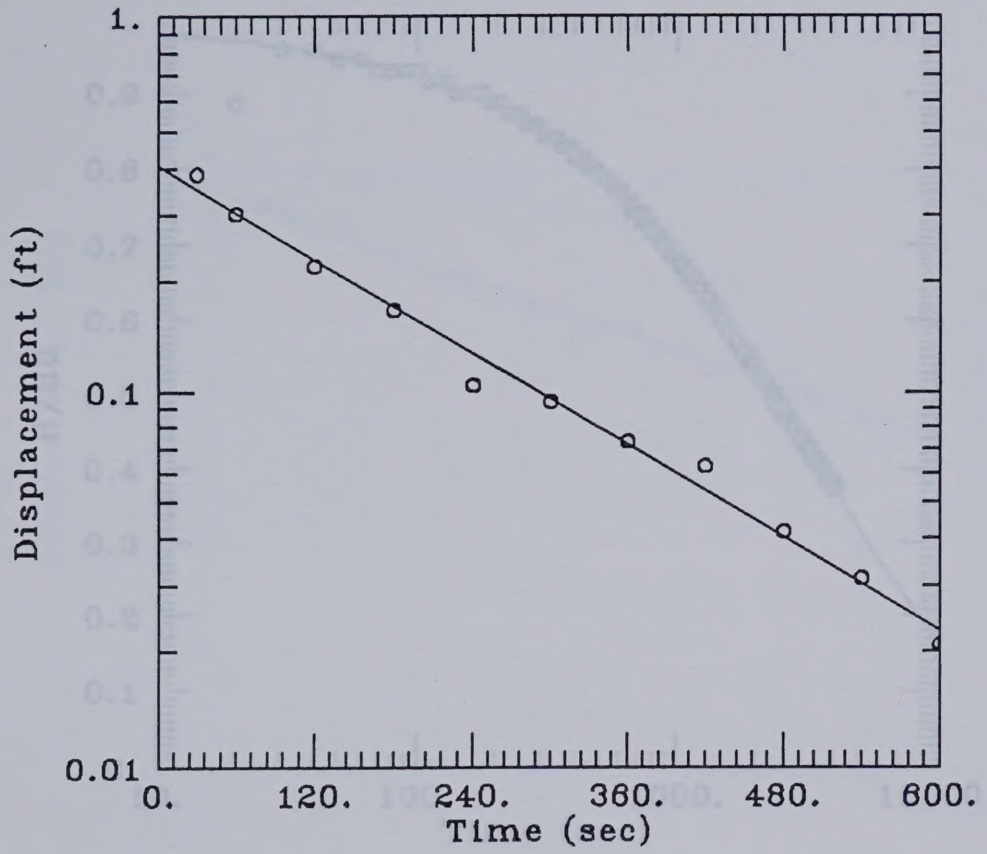
AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice

ESTIMATED PARAMETERS:
K = 3.2866E-05 ft/sec
y0 = 0.3858 ft

TEST DATA:
H0 = 1.617 ft
rc = 0.08333 ft
rw = 0.25 ft
L = 1. ft
b = 1. ft
H = 1. ft

MW-2 Slug Out

GeoResearch, Inc.	Client: City of Laurel
Project No.: 112035	Location: Laurel Landfill



DATA SET:
laurmw-2.dat
12/29/92

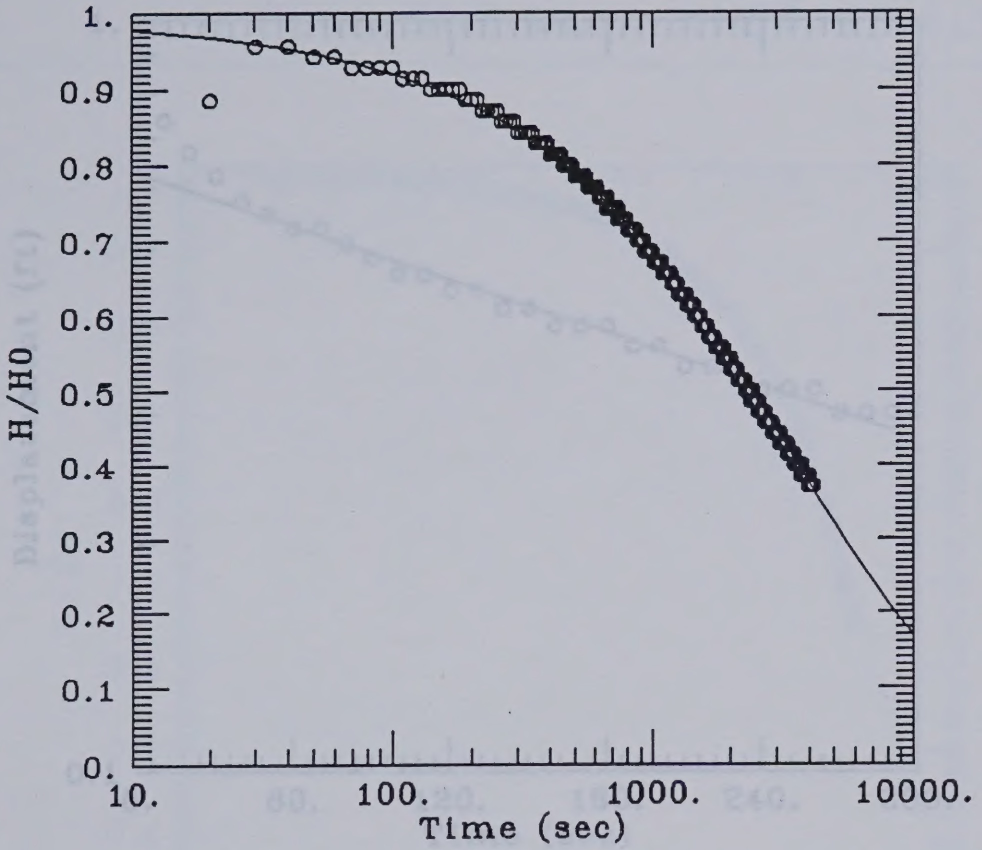
AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice

ESTIMATED PARAMETERS:
K = 1.5823E-05 ft/sec
y0 = 0.4048 ft

TEST DATA:
H0 = 1.2 ft
rc = 0.08333 ft
rw = 0.25 ft
L = 1.2 ft
b = 1.2 ft
H = 1.2 ft

MW-2 Slug Out

GeoResearch, Inc.
Client: City of Laurel
Project No.: 112035
Location: Laurel Landfill



DATA SET:
lmv-3in.dat
12/29/92

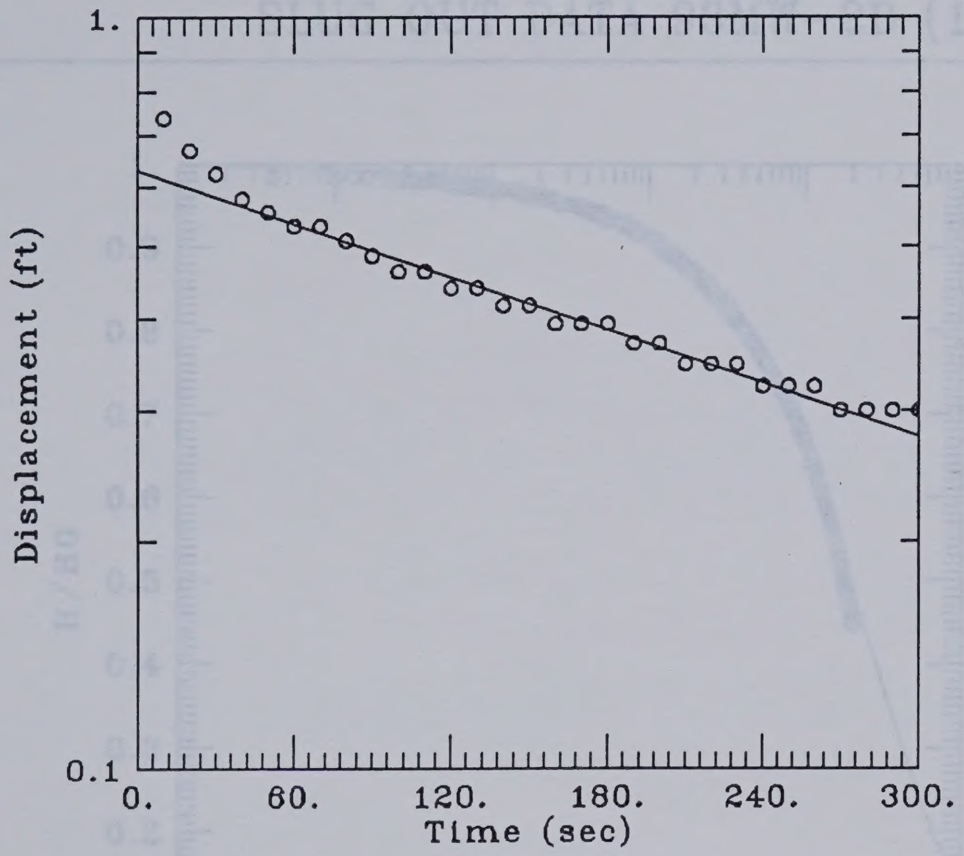
AQUIFER TYPE:
Confined
SOLUTION METHOD:
Cooper et al.

ESTIMATED PARAMETERS:
T = 1.8982E-06 ft^2/sec
S = 0.003

TEST DATA:
H0 = 1.617 ft
rc = 0.08333 ft
rw = 0.25 ft

MW-3 Slug In

GeoResearch, Inc.	Client: City of Laurel
Project No.: 112035	Location: Laurel Landfill



DATA SET:
14out.dat
12/29/92

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice

ESTIMATED PARAMETERS:
K = 9.7016E-06 ft/sec
y0 = 0.6309 ft

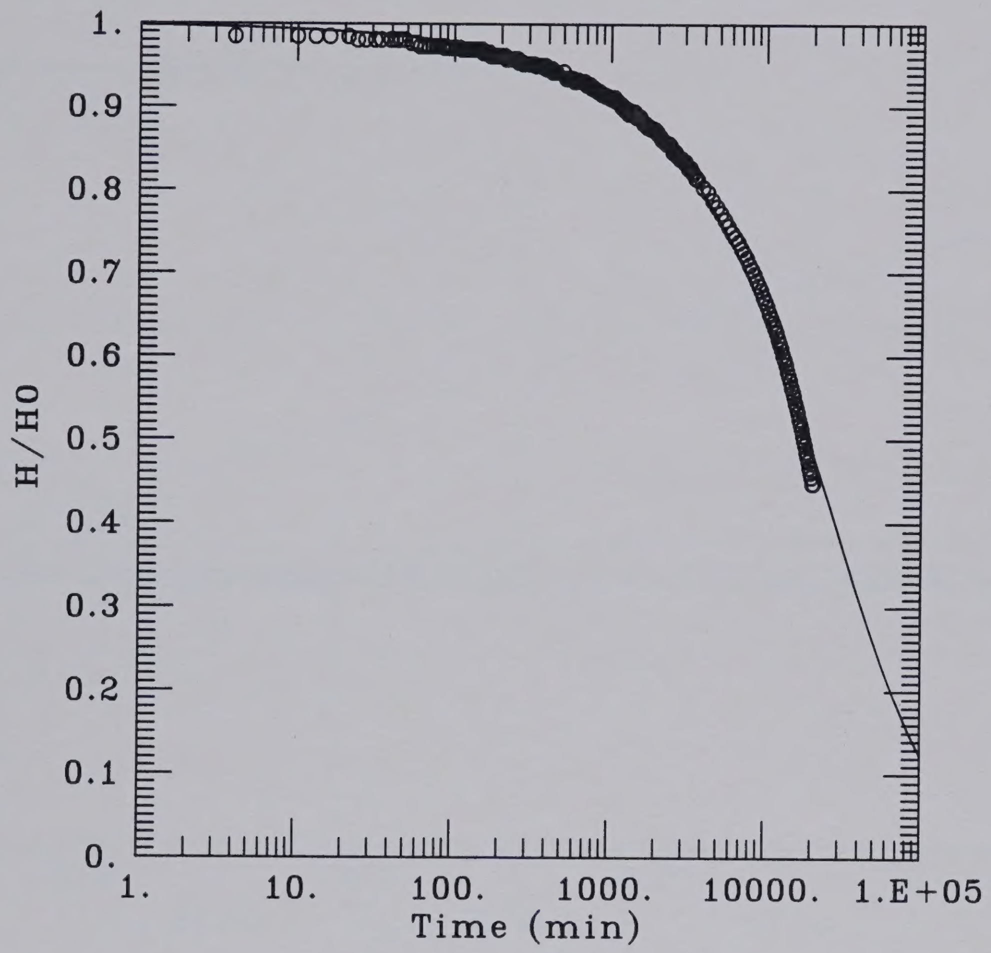
TEST DATA:
H0 = 1.617 ft
rc = 0.08333 ft
rw = 0.25 ft
L = 1. ft
b = 1. ft
H = 1. ft

MW-4 Slug Out

GeoResearch, Inc.
Client: City of Laurel
Project No.: 112035
Location: Laurel Landfill

GeoResearch, Inc.	Client: **City of Laurel**
Project No.: 112035	Location: **Laurel Landfill**

SLUG OUT DATA 93MW-2D (11/93)



DATA SET:
so-2dn93.dat
02/03/94

AQUIFER TYPE:
Confined

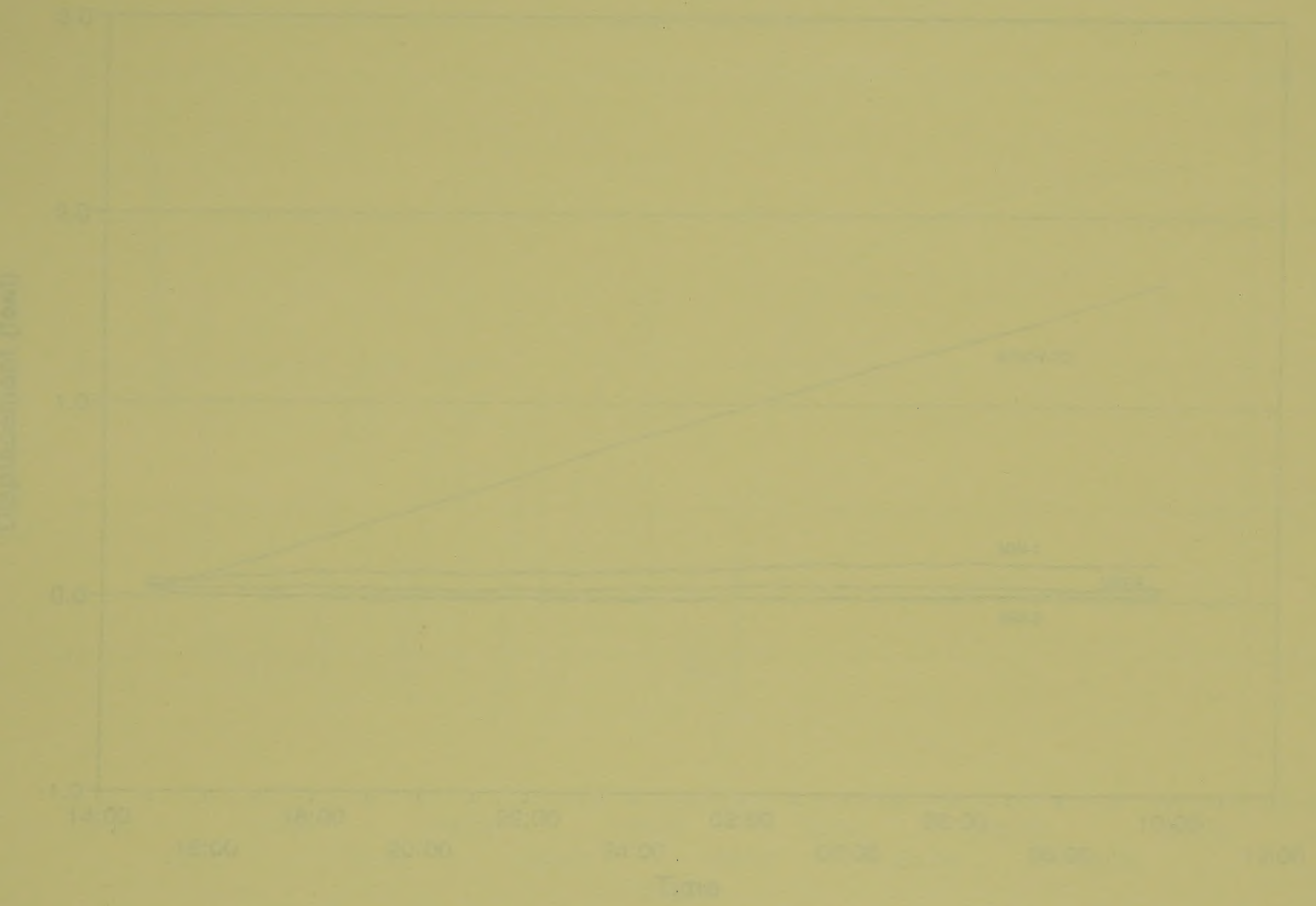
SOLUTION METHOD:
Cooper et al.

ESTIMATED PARAMETERS:
T = 2.7056E-07 ft^2/min
S = 0.001982

TEST DATA:
H0 = 2.59 ft
rc = 0.08333 ft
rw = 0.25 ft

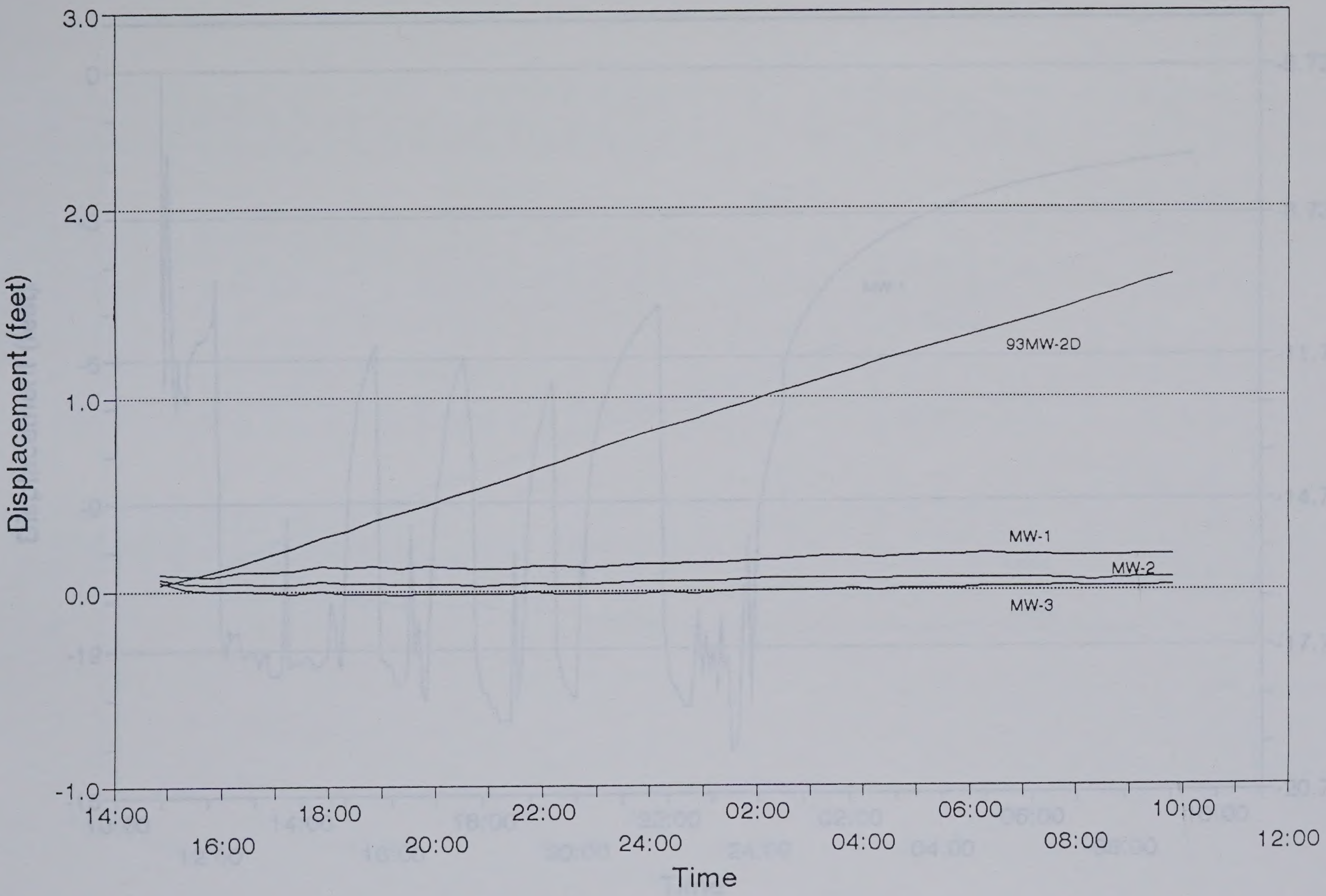
Static Water Levels

Laurel Landfill, September 14-15, 1993



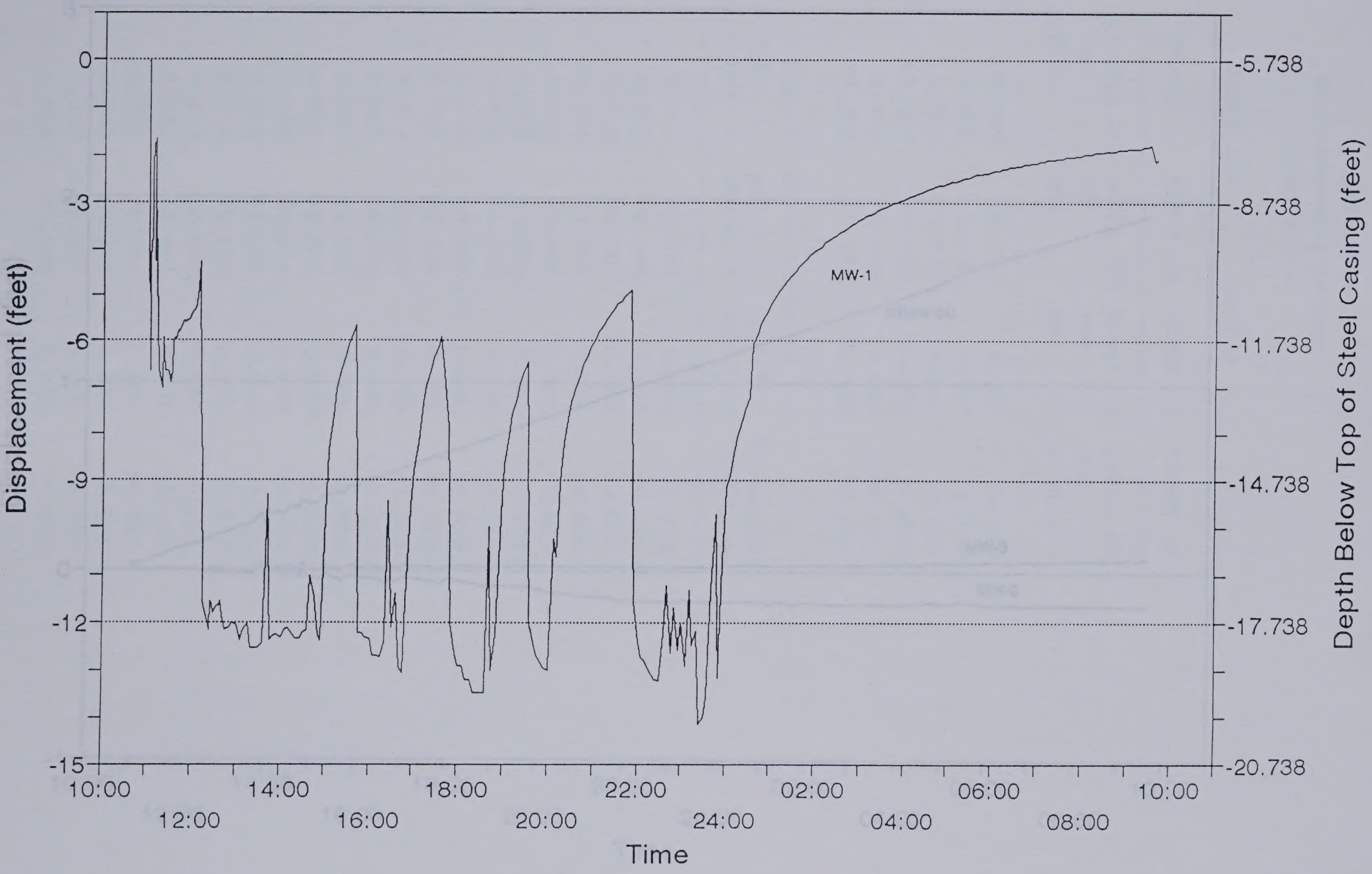
Static Water Levels

Laurel Landfill, September 14-15, 1993



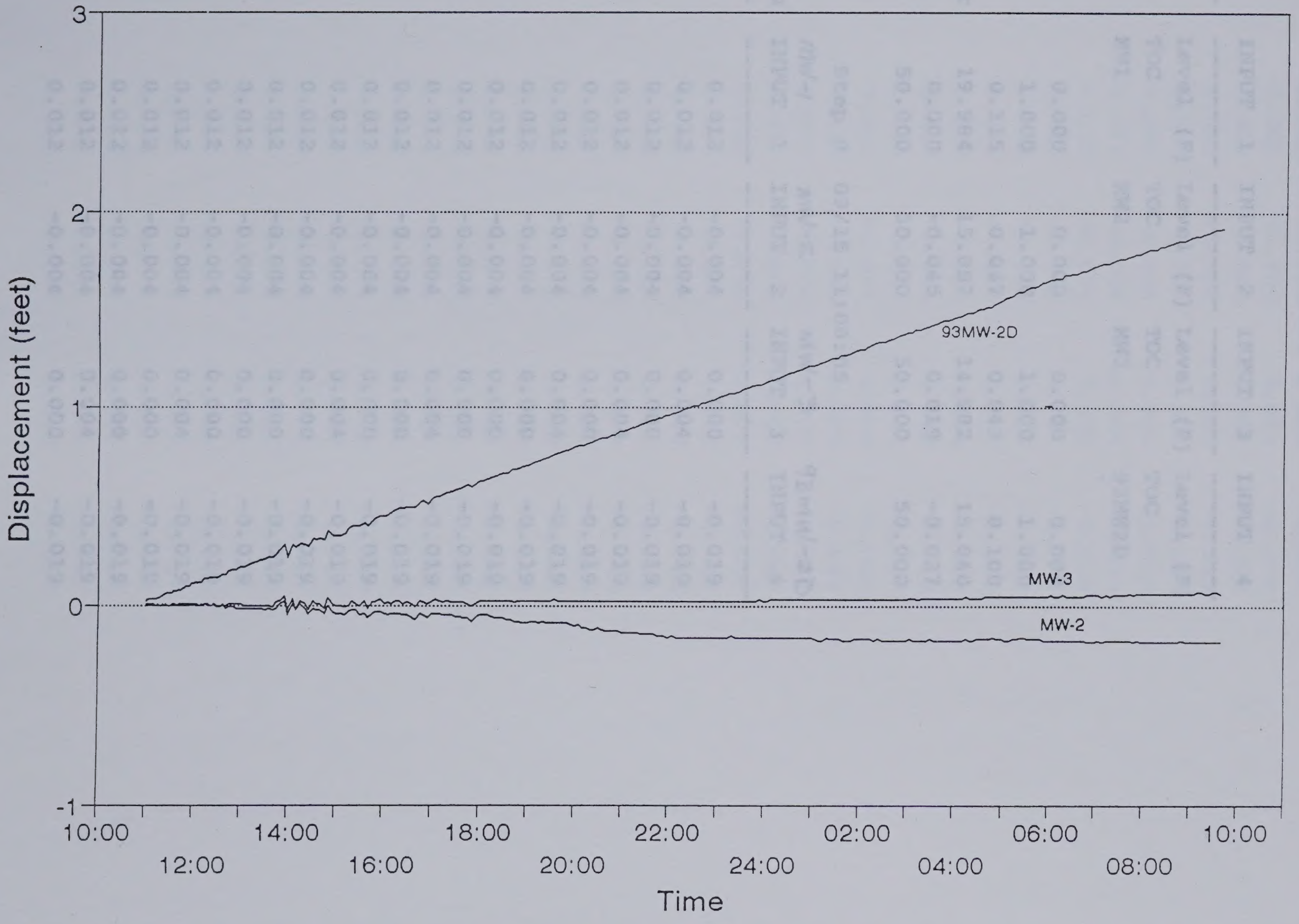
Pumping Well Water Levels

Laurel Landfill, September 15-16, 1993



Observation Well Water Levels

Laurel Landfill, September 15-16, 1993



```
                       SE2000
                 Environmental Logger
                     09/16 15:10

                Unit# 120        Test 4

etups:        INPUT   1  INPUT   2  INPUT   3  INPUT   4
-----------   ---------  ---------  ---------  ---------
ype           Level (F)  Level (F)  Level (F)  Level (F)
ode           TOC        TOC        TOC        TOC
.D.           MW1        MW2        MW3        93MW2D

eference          0.000      0.000      0.000      0.000
G                 1.000      1.000      1.000      1.000
inearity          0.115      0.067      0.043      0.100
cale factor      19.984     15.057     14.982     15.040
ffset             0.000     -0.045      0.019     -0.027
elay mSEC        50.000     50.000     50.000     50.000

                Step 0   09/15 11:00:05
              MW-1       MW-2       MW-3       93MW-2D
lapsed Time   INPUT   1  INPUT   2  INPUT   3  INPUT   4
-----------   ---------  ---------  ---------  ---------
   0.0000         0.012     -0.004      0.000     -0.019
   0.0083         0.012     -0.004      0.004     -0.019
   0.0166         0.012     -0.004      0.000     -0.019
   0.0250         0.012     -0.004      0.004     -0.019
   0.0333         0.012     -0.004      0.000     -0.019
   0.0416         0.012     -0.004      0.004     -0.019
   0.0500         0.012     -0.004      0.000     -0.019
   0.0583         0.012     -0.004      0.000     -0.019
   0.0666         0.012     -0.004      0.000     -0.019
   0.0750         0.012     -0.004      0.004     -0.019
   0.0833         0.012     -0.004      0.000     -0.019
   0.0916         0.012     -0.004      0.000     -0.019
   0.1000         0.012     -0.004      0.004     -0.019
   0.1083         0.012     -0.004      0.000     -0.019
   0.1166         0.012     -0.004      0.000     -0.019
   0.1250         0.012     -0.004      0.000     -0.019
   0.1333         0.012     -0.004      0.000     -0.019
   0.1416         0.012     -0.004      0.004     -0.019
   0.1500         0.012     -0.004      0.000     -0.019
   0.1583         0.012     -0.004      0.000     -0.019
   0.1666         0.012     -0.004      0.004     -0.019
   0.1750         0.012     -0.004      0.000     -0.019
```

0.1833	0.012	-0.004	0.000	-0.019
0.1916	0.012	-0.004	0.004	-0.019
0.2000	0.012	-0.004	0.004	-0.019
0.2083	0.006	-0.004	0.004	-0.019
0.2166	0.012	-0.004	0.004	-0.019
0.2250	0.012	-0.004	0.004	-0.019
0.2333	0.006	-0.004	0.004	-0.019
0.2416	0.012	-0.004	0.000	-0.019
0.2500	0.012	-0.004	0.000	-0.019
0.2583	0.012	-0.004	0.004	-0.019
0.2666	0.012	-0.004	0.004	-0.019
0.2750	0.012	-0.004	0.004	-0.019
0.2833	0.012	-0.004	0.004	-0.019
0.2916	0.012	-0.004	0.004	-0.019
0.3000	0.012	-0.004	0.004	-0.019
0.3083	0.012	-0.004	0.004	-0.019
0.3166	0.012	-0.004	0.004	-0.019
0.3250	0.012	-0.004	0.004	-0.019
0.3333	0.012	-0.004	0.004	-0.019
0.3500	0.012	-0.004	0.004	-0.019
0.3666	0.012	-0.004	0.000	-0.019
0.3833	0.012	-0.004	0.004	-0.019
0.4000	0.012	-0.004	0.000	-0.019
0.4166	0.012	-0.004	0.004	-0.019
0.4333	0.012	-0.004	0.004	-0.019
0.4500	0.012	-0.004	0.000	-0.019
0.4666	0.012	-0.004	0.004	-0.019
0.4833	0.012	-0.004	0.004	-0.019
0.5000	0.012	-0.004	0.004	-0.019
0.5166	0.012	-0.004	0.000	-0.019
0.5333	0.012	-0.004	0.000	-0.019
0.5500	0.012	-0.004	0.000	-0.019
0.5666	0.012	-0.004	0.004	-0.019
0.5833	0.012	-0.004	0.004	-0.019
0.6000	0.012	-0.004	0.004	-0.019
0.6166	0.012	-0.004	0.004	-0.019
0.6333	0.057	-0.004	0.000	-0.019
0.6500	0.044	-0.004	0.004	-0.019
0.6666	0.031	-0.004	0.004	-0.019
0.6833	0.038	-0.004	0.004	-0.019
0.7000	0.019	-0.004	0.000	-0.019
0.7166	0.012	-0.004	0.000	-0.019
0.7333	0.006	-0.004	0.000	-0.019
0.7500	0.012	-0.004	0.004	-0.019
0.7666	0.012	-0.004	0.000	-0.019
0.7833	0.012	-0.004	0.000	-0.019

0.8000	0.012	-0.004	0.004	-0.019
0.8166	0.012	-0.004	0.000	-0.019
0.8333	0.012	-0.004	0.004	-0.019
0.8500	0.012	-0.004	0.004	-0.019
0.8666	0.133	-0.004	0.000	-0.019
0.8833	0.088	-0.004	0.004	-0.019
0.9000	0.139	-0.004	0.000	-0.019
0.9166	0.196	-0.004	0.004	-0.019
0.9333	0.228	-0.004	0.000	-0.019
0.9500	0.310	-0.004	0.004	-0.019
0.9666	0.399	-0.004	0.004	-0.019
0.9833	0.538	-0.004	0.000	-0.019
1.0000	0.659	-0.004	0.000	-0.019
1.2000	1.806	-0.004	0.000	-0.023
1.4000	2.699	-0.004	0.000	-0.023
1.6000	3.459	-0.004	0.000	-0.023
1.8000	4.067	-0.009	0.000	-0.023
2.0000	4.625	-0.009	-0.004	-0.023
2.2000	5.081	-0.009	0.000	-0.028
2.4000	5.486	-0.009	-0.004	-0.028
2.6000	5.828	-0.009	-0.004	-0.028
2.8000	6.144	-0.009	-0.004	-0.028
3.0000	6.416	-0.009	-0.004	-0.028
3.2000	6.651	-0.009	0.000	-0.023
3.4000	6.170	-0.009	0.000	-0.023
3.6000	4.327	-0.004	0.000	-0.028
3.8000	4.859	-0.004	0.004	-0.028
4.0000	4.181	-0.004	0.000	-0.028
4.2000	3.668	-0.004	0.000	-0.028
4.4000	3.333	-0.004	0.000	-0.028
4.6000	3.086	-0.004	0.000	-0.028
4.8000	2.883	-0.004	0.000	-0.028
5.0000	2.706	-0.004	-0.004	-0.028
5.2000	2.528	-0.009	0.000	-0.028
5.4000	2.376	-0.004	-0.004	-0.028
5.6000	2.243	-0.009	0.000	-0.028
5.8000	2.148	-0.009	-0.004	-0.033
6.0000	2.072	-0.009	0.000	-0.033
6.2000	1.952	-0.009	-0.004	-0.033
6.4000	1.876	-0.009	0.000	-0.033
6.6000	1.945	-0.009	0.000	-0.033
6.8000	1.933	-0.009	0.000	-0.033
7.0000	1.888	-0.009	0.004	-0.033
7.2000	1.844	-0.004	0.004	-0.033
7.4000	1.812	-0.004	0.000	-0.033
7.6000	1.787	-0.004	0.004	-0.033

```
 7.8000       1.755   -0.004    0.000   -0.033
 8.0000       1.762   -0.004    0.000   -0.028
 8.2000       1.736   -0.004    0.000   -0.028
 8.4000       1.711   -0.004    0.004   -0.033
 8.6000       1.673   -0.004    0.004   -0.028
 8.8000       1.666   -0.004    0.004   -0.028
 9.0000       1.660   -0.004    0.004   -0.033
 9.2000       2.547   -0.004    0.004   -0.033
 9.4000       3.263   -0.004    0.004   -0.033
 9.6000       3.789   -0.004    0.000   -0.033
 9.8000       4.245   -0.004    0.000   -0.033
10.0000       3.193   -0.004    0.004   -0.033
12.0000       5.644    0.000    0.000   -0.028
14.0000       6.625    0.000    0.004   -0.033
16.0000       6.872   -0.004    0.000   -0.038
18.0000       7.024    0.000    0.000   -0.038
20.0000       5.935    0.000    0.000   -0.042
22.0000       6.644    0.000   -0.004   -0.047
24.0000       6.651    0.000    0.000   -0.052
26.0000       6.670   -0.004    0.004   -0.052
28.0000       6.682    0.000    0.000   -0.057
30.0000       6.910    0.000    0.004   -0.057
32.0000       6.644    0.000    0.000   -0.061
34.0000       6.011   -0.004    0.000   -0.061
36.0000       5.929   -0.004    0.004   -0.066
38.0000       5.967   -0.004    0.000   -0.066
40.0000       5.777    0.000    0.000   -0.071
42.0000       5.821   -0.004    0.000   -0.076
44.0000       5.707   -0.004    0.004   -0.076
46.0000       5.625   -0.004    0.004   -0.081
48.0000       5.562   -0.004    0.000   -0.085
50.0000       5.606   -0.009    0.000   -0.090
52.0000       5.556   -0.004    0.000   -0.090
54.0000       5.549   -0.004    0.000   -0.090
56.0000       5.518   -0.004    0.000   -0.095
58.0000       5.448   -0.004   -0.004   -0.104
60.0000       5.378   -0.004    0.000   -0.104
62.0000       5.328   -0.004   -0.004   -0.109
64.0000       5.277   -0.004    0.000   -0.114
66.0000       5.169    0.000   -0.004   -0.109
68.0000       4.840    0.000    0.000   -0.114
70.0000       4.264    0.000   -0.004   -0.119
72.0000       7.246    0.000    0.000   -0.123
74.0000       8.656   -0.004   -0.004   -0.128
76.0000      11.578   -0.004   -0.004   -0.128
78.0000      11.768    0.000   -0.004   -0.128
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80.0000	11.982	0.000	-0.004	-0.133
82.0000	12.166	0.004	0.000	-0.138
84.0000	11.559	0.000	0.000	-0.138
86.0000	11.622	-0.004	-0.009	-0.142
88.0000	11.812	0.000	-0.004	-0.142
90.0000	11.755	0.009	0.000	-0.142
92.0000	11.698	0.009	0.004	-0.142
94.0000	11.673	0.009	0.004	-0.147
96.0000	11.654	0.004	-0.004	-0.152
98.0000	11.572	0.004	0.000	-0.157
100.000	11.869	0.014	0.000	-0.157
105.000	12.153	0.009	-0.004	-0.171
110.000	12.096	0.009	-0.004	-0.176
115.000	12.014	0.014	-0.004	-0.181
120.000	12.058	0.014	-0.004	-0.195
125.000	12.374	0.019	0.000	-0.190
130.000	12.172	0.014	0.000	-0.200
135.000	12.033	0.019	0.004	-0.209
140.000	12.539	0.019	0.004	-0.214
145.000	12.539	0.019	0.000	-0.224
150.000	12.539	0.023	0.000	-0.233
155.000	12.450	0.014	0.004	-0.238
160.000	9.314	0.023	0.009	-0.238
165.000	12.387	0.014	-0.014	-0.257
170.000	12.292	-0.004	-0.023	-0.281
175.000	12.248	-0.019	-0.042	-0.305
180.000	12.311	0.047	0.028	-0.243
185.000	12.166	-0.004	-0.028	-0.300
190.000	12.134	0.023	0.014	-0.285
195.000	12.261	-0.004	-0.023	-0.309
200.000	12.343	0.014	-0.004	-0.300
205.000	12.349	0.042	0.023	-0.295
210.000	12.235	0.014	-0.019	-0.333
215.000	12.153	0.023	-0.009	-0.328
220.000	11.041	0.028	-0.004	-0.338
225.000	11.477	0.042	0.014	-0.328
230.000	12.299	0.000	-0.038	-0.371
235.000	12.393	0.033	-0.004	-0.347
240.000	9.770	0.038	0.000	-0.352
245.000	8.340	0.038	0.000	-0.352
250.000	7.613	0.052	0.009	-0.357
255.000	7.062	0.033	0.000	-0.381
260.000	6.657	0.023	-0.019	-0.395
265.000	6.347	0.028	-0.009	-0.400
270.000	6.081	0.047	0.000	-0.395
275.000	5.828	0.038	-0.019	-0.414

280.000	5.638	0.061	0.014	-0.400
285.000	12.235	0.038	-0.014	-0.424
290.000	12.229	0.033	-0.014	-0.433
295.000	12.317	0.033	-0.028	-0.448
300.000	12.368	0.042	-0.004	-0.448
305.000	12.703	0.047	-0.014	-0.452
310.000	12.703	0.042	-0.009	-0.467
315.000	12.716	0.038	-0.019	-0.476
320.000	12.425	0.042	-0.019	-0.486
325.000	9.428	0.047	-0.009	-0.481
330.000	12.115	0.047	-0.014	-0.490
335.000	11.401	0.061	-0.004	-0.490
340.000	12.943	0.071	0.009	-0.490
345.000	13.076	0.042	-0.019	-0.514
350.000	11.546	0.047	-0.014	-0.519
355.000	9.574	0.061	-0.004	-0.510
360.000	8.783	0.042	-0.014	-0.533
365.000	8.188	0.042	-0.028	-0.543
370.000	7.359	0.042	-0.019	-0.548
375.000	6.973	0.047	-0.014	-0.557
380.000	6.644	0.047	-0.019	-0.562
385.000	6.385	0.052	-0.014	-0.567
390.000	6.144	0.057	-0.014	-0.576
395.000	5.904	0.057	-0.014	-0.586
400.000	6.701	0.066	-0.014	-0.591
405.000	7.872	0.066	-0.009	-0.600
410.000	12.052	0.080	0.000	-0.591
415.000	12.652	0.061	-0.009	-0.605
420.000	12.924	0.052	-0.019	-0.624
425.000	12.930	0.052	-0.019	-0.624
430.000	13.209	0.052	-0.023	-0.634
435.000	13.215	0.057	-0.019	-0.643
440.000	13.493	0.061	-0.019	-0.648
445.000	13.493	0.061	-0.019	-0.653
450.000	13.493	0.066	-0.019	-0.662
455.000	13.474	0.071	-0.019	-0.667
460.000	10.004	0.076	-0.019	-0.676
465.000	13.013	0.080	-0.014	-0.681
470.000	12.248	0.080	-0.019	-0.686
475.000	9.713	0.085	-0.023	-0.695
480.000	8.644	0.085	-0.023	-0.700
485.000	8.036	0.080	-0.023	-0.710
490.000	7.600	0.080	-0.023	-0.719
495.000	7.252	0.085	-0.019	-0.724
500.000	6.948	0.080	-0.019	-0.734
505.000	6.695	0.085	-0.019	-0.738

510.000	6.461	0.085	-0.019	-0.748
515.000	11.995	0.085	-0.028	-0.757
520.000	12.457	0.090	-0.019	-0.767
525.000	12.690	0.090	-0.023	-0.772
530.000	12.855	0.090	-0.023	-0.781
535.000	12.956	0.095	-0.023	-0.786
540.000	13.006	0.100	-0.023	-0.796
545.000	10.269	0.095	-0.023	-0.805
550.000	10.617	0.109	-0.019	-0.805
555.000	9.023	0.109	-0.023	-0.815
560.000	8.201	0.119	-0.019	-0.819
565.000	7.682	0.119	-0.019	-0.824
570.000	7.302	0.114	-0.023	-0.839
575.000	6.999	0.123	-0.023	-0.843
580.000	6.739	0.128	-0.019	-0.843
585.000	6.511	0.128	-0.023	-0.858
590.000	6.321	0.128	-0.023	-0.862
595.000	6.132	0.128	-0.023	-0.872
600.000	5.980	0.133	-0.023	-0.877
605.000	5.821	0.133	-0.023	-0.881
610.000	5.688	0.138	-0.019	-0.891
615.000	5.562	0.138	-0.019	-0.896
620.000	5.442	0.138	-0.019	-0.905
625.000	5.321	0.142	-0.019	-0.915
630.000	5.195	0.142	-0.019	-0.924
635.000	5.125	0.142	-0.019	-0.929
640.000	5.017	0.142	-0.023	-0.939
645.000	4.935	0.147	-0.019	-0.943
650.000	4.865	0.152	-0.019	-0.948
655.000	11.572	0.147	-0.023	-0.958
660.000	12.406	0.157	-0.019	-0.962
665.000	12.728	0.152	-0.019	-0.972
670.000	12.804	0.157	-0.019	-0.977
675.000	12.981	0.157	-0.019	-0.986
680.000	13.114	0.157	-0.019	-0.991
685.000	13.190	0.161	-0.023	-1.001
690.000	13.221	0.157	-0.023	-1.005
695.000	12.223	0.157	-0.019	-1.010
700.000	11.224	0.157	-0.023	-1.020
705.000	12.640	0.157	-0.023	-1.024
710.000	11.704	0.157	-0.023	-1.034
715.000	12.589	0.157	-0.023	-1.039
720.000	11.995	0.157	-0.023	-1.048
725.000	12.930	0.157	-0.023	-1.053
730.000	11.312	0.157	-0.023	-1.063
735.000	12.482	0.157	-0.023	-1.067

740.000	12.185	0.152	-0.023	-1.072
745.000	14.150	0.157	-0.023	-1.082
750.000	14.024	0.157	-0.023	-1.086
755.000	13.569	0.157	-0.023	-1.091
760.000	11.319	0.157	-0.023	-1.101
765.000	9.738	0.157	-0.023	-1.106
770.000	13.177	0.161	-0.019	-1.115
775.000	10.687	0.157	-0.028	-1.120
780.000	9.131	0.157	-0.023	-1.125
785.000	8.922	0.157	-0.023	-1.134
790.000	8.416	0.157	-0.028	-1.139
795.000	8.011	0.157	-0.028	-1.148
800.000	7.695	0.157	-0.028	-1.158
805.000	7.467	0.161	-0.028	-1.168
810.000	7.214	0.161	-0.028	-1.172
815.000	6.075	0.161	-0.028	-1.182
820.000	5.828	0.161	-0.028	-1.187
825.000	5.619	0.161	-0.028	-1.196
830.000	5.442	0.161	-0.028	-1.201
835.000	5.283	0.161	-0.028	-1.210
840.000	5.144	0.161	-0.028	-1.215
845.000	5.011	0.166	-0.028	-1.220
850.000	4.891	0.171	-0.028	-1.230
855.000	4.777	0.171	-0.028	-1.234
860.000	4.669	0.161	-0.033	-1.244
865.000	4.561	0.166	-0.028	-1.249
870.000	4.466	0.166	-0.028	-1.253
875.000	4.378	0.166	-0.028	-1.263
880.000	4.289	0.171	-0.028	-1.268
885.000	4.213	0.171	-0.033	-1.277
890.000	4.131	0.171	-0.028	-1.282
895.000	4.061	0.166	-0.028	-1.292
900.000	3.991	0.166	-0.033	-1.296
905.000	3.922	0.166	-0.028	-1.301
910.000	3.852	0.166	-0.033	-1.311
915.000	3.789	0.166	-0.033	-1.320
920.000	3.738	0.171	-0.033	-1.330
925.000	3.675	0.166	-0.033	-1.334
930.000	3.618	0.171	-0.033	-1.339
935.000	3.573	0.171	-0.033	-1.344
940.000	3.523	0.176	-0.033	-1.354
945.000	3.472	0.171	-0.033	-1.358
950.000	3.421	0.171	-0.033	-1.368
955.000	3.371	0.171	-0.033	-1.373
960.000	3.333	0.171	-0.033	-1.382
965.000	3.282	0.166	-0.038	-1.387

970.000	3.244	0.171	-0.038	-1.396
975.000	3.200	0.171	-0.033	-1.401
980.000	3.162	0.171	-0.038	-1.406
985.000	3.124	0.171	-0.038	-1.416
990.000	3.086	0.166	-0.038	-1.420
995.000	3.048	0.171	-0.038	-1.430
1000.00	3.016	0.171	-0.038	-1.435
1005.00	2.978	0.171	-0.038	-1.444
1010.00	2.946	0.171	-0.038	-1.449
1015.00	2.915	0.171	-0.038	-1.454
1020.00	2.889	0.176	-0.038	-1.463
1025.00	2.858	0.171	-0.038	-1.468
1030.00	2.826	0.171	-0.038	-1.477
1035.00	2.794	0.166	-0.042	-1.482
1040.00	2.763	0.171	-0.038	-1.487
1045.00	2.737	0.171	-0.038	-1.497
1050.00	2.712	0.166	-0.038	-1.506
1055.00	2.687	0.166	-0.038	-1.511
1060.00	2.655	0.166	-0.042	-1.516
1065.00	2.630	0.166	-0.042	-1.520
1070.00	2.604	0.161	-0.042	-1.535
1075.00	2.579	0.166	-0.042	-1.544
1080.00	2.560	0.166	-0.042	-1.554
1085.00	2.541	0.171	-0.042	-1.563
1090.00	2.516	0.171	-0.047	-1.573
1095.00	2.490	0.166	-0.047	-1.578
1100.00	2.465	0.166	-0.042	-1.592
1105.00	2.446	0.161	-0.047	-1.597
1110.00	2.421	0.161	-0.047	-1.606
1115.00	2.408	0.166	-0.047	-1.616
1120.00	2.389	0.166	-0.042	-1.621
1125.00	2.363	0.166	-0.047	-1.630
1130.00	2.351	0.166	-0.047	-1.640
1135.00	2.332	0.171	-0.047	-1.644
1140.00	2.313	0.171	-0.047	-1.654
1145.00	2.300	0.171	-0.052	-1.659
1150.00	2.281	0.171	-0.047	-1.663
1155.00	2.262	0.171	-0.047	-1.668
1160.00	2.243	0.171	-0.052	-1.678
1165.00	2.230	0.171	-0.047	-1.683
1170.00	2.218	0.171	-0.047	-1.687
1175.00	2.199	0.176	-0.047	-1.692
1180.00	2.186	0.176	-0.047	-1.702
1185.00	2.173	0.176	-0.047	-1.706
1190.00	2.161	0.180	-0.052	-1.716
1195.00	2.142	0.180	-0.052	-1.721

1200.00	2.129	0.180	-0.052	-1.726
1205.00	2.116	0.176	-0.052	-1.735
1210.00	2.097	0.180	-0.047	-1.740
1215.00	2.085	0.176	-0.052	-1.745
1220.00	2.072	0.176	-0.047	-1.749
1225.00	2.059	0.176	-0.052	-1.759
1230.00	2.047	0.176	-0.052	-1.764
1235.00	2.028	0.176	-0.052	-1.768
1240.00	2.015	0.176	-0.052	-1.778
1245.00	2.009	0.176	-0.057	-1.783
1250.00	1.996	0.180	-0.052	-1.788
1255.00	1.983	0.176	-0.057	-1.792
1260.00	1.971	0.180	-0.057	-1.802
1265.00	1.958	0.180	-0.061	-1.811
1270.00	1.952	0.180	-0.057	-1.816
1275.00	1.939	0.180	-0.057	-1.816
1280.00	1.933	0.185	-0.057	-1.826
1285.00	1.920	0.180	-0.061	-1.830
1290.00	1.907	0.180	-0.057	-1.840
1295.00	1.895	0.180	-0.057	-1.845
1300.00	1.888	0.180	-0.057	-1.850
1305.00	1.876	0.180	-0.061	-1.859
1310.00	1.863	0.176	-0.061	-1.864
1315.00	1.850	0.180	-0.061	-1.869
1320.00	1.844	0.185	-0.061	-1.873
1325.00	1.838	0.185	-0.057	-1.883
1330.00	1.825	0.180	-0.066	-1.888
1335.00	1.819	0.180	-0.066	-1.892
1340.00	1.806	0.185	-0.061	-1.897
1345.00	1.793	0.185	-0.061	-1.907
1350.00	1.781	0.180	-0.066	-1.912
1355.00	2.110	0.180	-0.066	-1.916
1360.00	2.091	0.180	-0.061	-1.926

APPENDIX E

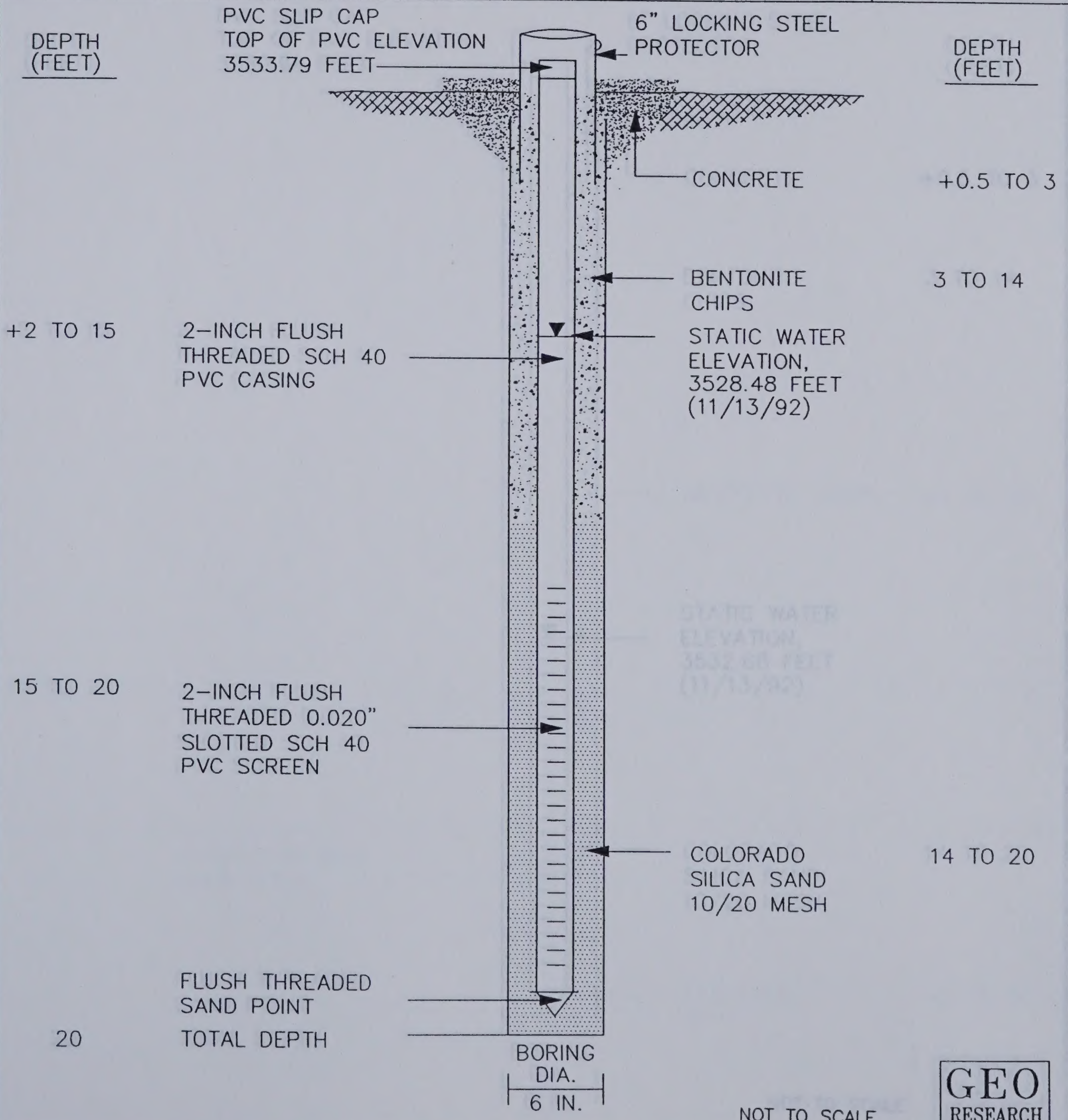
WELL COMPLETION LOGS

MONITORING WELL COMPLETION LOG

PROJECT 112035
SITE LAUREL LANDFILL
LOCATION SEE MAP

HYDROGEOLOGIST CURT COOVER
DRILLER PRO PUMP
DATE OCTOBER 27, 1992

HOLE I.D.
MW–1


DEPTH (FEET)
PVC SLIP CAP
TOP OF PVC ELEVATION
3533.79 FEET
6" LOCKING STEEL PROTECTOR
DEPTH (FEET)
CONCRETE
+0.5 TO 3
BENTONITE CHIPS
3 TO 14
+2 TO 15
2–INCH FLUSH THREADED SCH 40 PVC CASING
STATIC WATER ELEVATION, 3528.48 FEET (11/13/92)
15 TO 20
2–INCH FLUSH THREADED 0.020" SLOTTED SCH 40 PVC SCREEN
COLORADO SILICA SAND 10/20 MESH
14 TO 20
FLUSH THREADED SAND POINT
20
TOTAL DEPTH
BORING DIA.
6 IN.

NOT TO SCALE

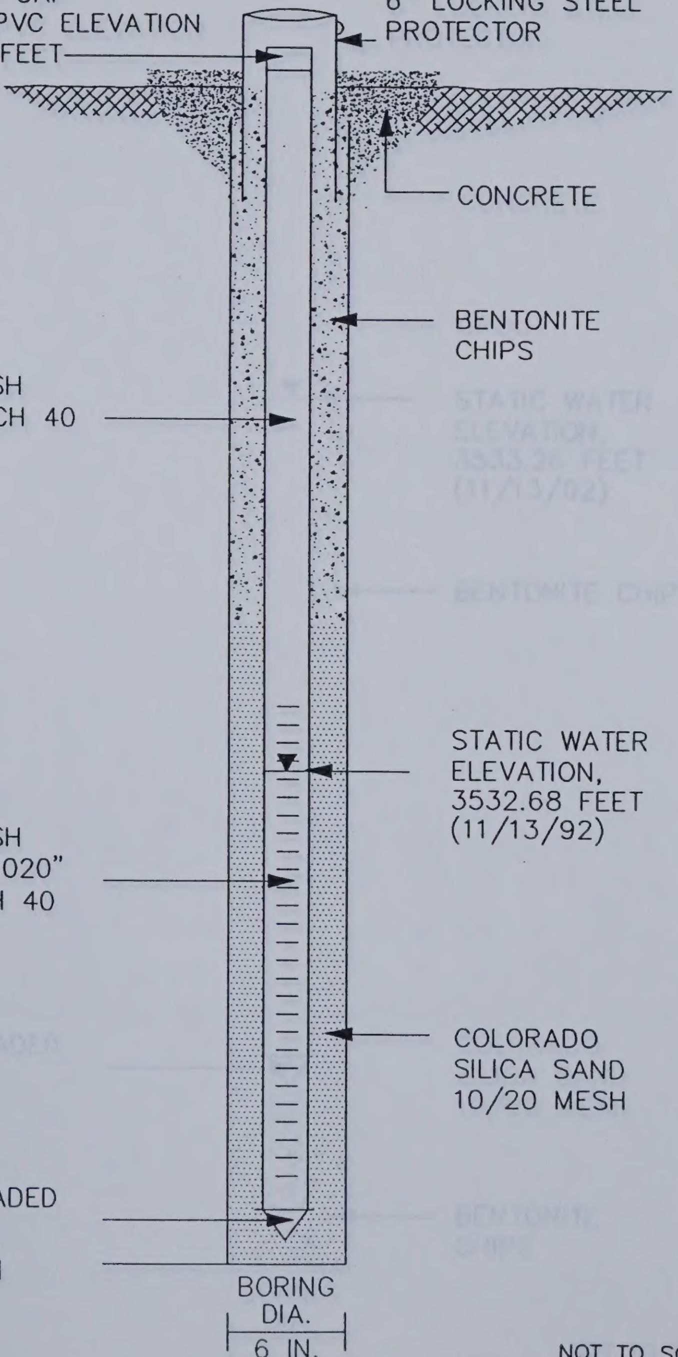
GEO RESEARCH

MONITORING WELL COMPLETION LOG

PROJECT 112035
SITE LAUREL LANDFILL
LOCATION SEE MAP

HYDROGEOLOGIST CURT COOVER
DRILLER PRO PUMP
DATE OCTOBER 27, 1992

HOLE I.D.
MW-2



PVC SLIP CAP
TOP OF PVC ELEVATION
3550.94 FEET

6" LOCKING STEEL PROTECTOR

STATIC WATER ELEVATION,
3532.68 FEET
(11/13/92)

DEPTH (FEET)	
+2 TO 15	2-INCH FLUSH THREADED SCH 40 PVC CASING
15 TO 20	2-INCH FLUSH THREADED 0.020" SLOTTED SCH 40 PVC SCREEN
	FLUSH THREADED SAND POINT
20	TOTAL DEPTH

	DEPTH (FEET)
CONCRETE	+0.5 TO 3
BENTONITE CHIPS	3 TO 14
COLORADO SILICA SAND 10/20 MESH	14 TO 20

NOT TO SCALE

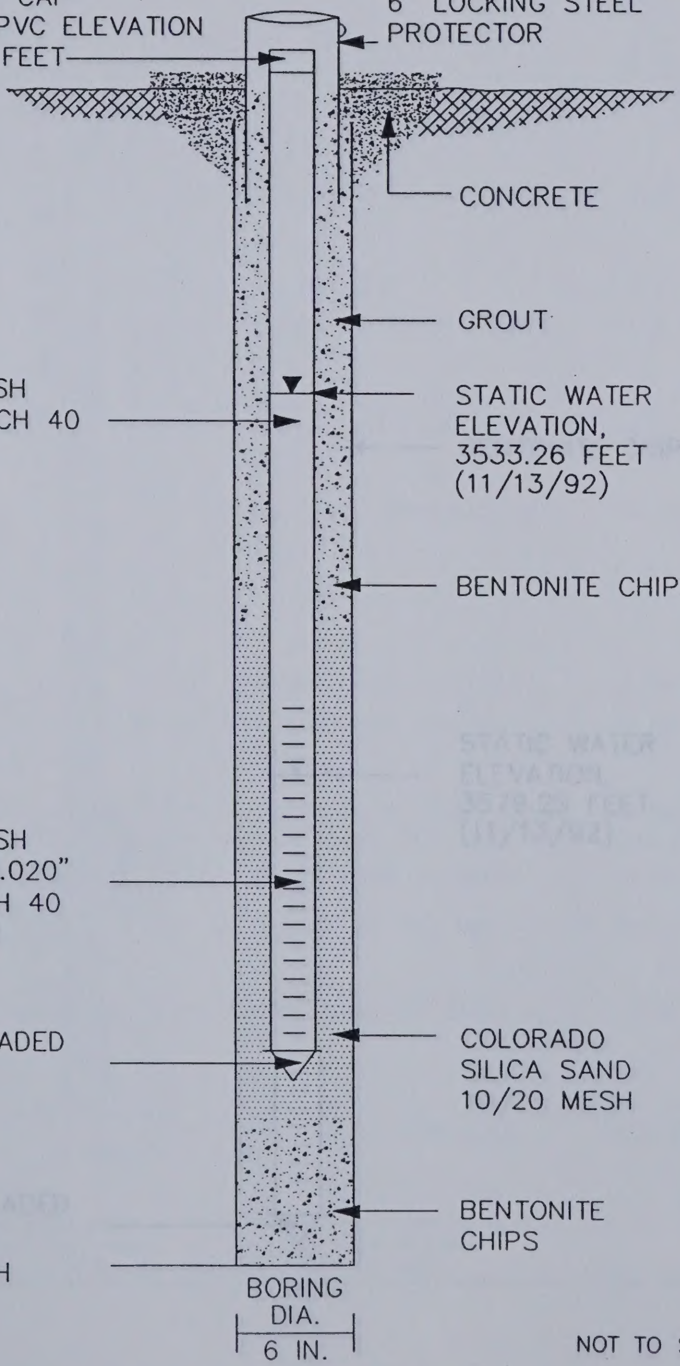
GEO RESEARCH

MONITORING WELL COMPLETION LOG

PROJECT 112035
SITE LAUREL LANDFILL
LOCATION SEE MAP

HYDROGEOLOGIST CURT COOVER
DRILLER PRO PUMP
DATE OCTOBER 28, 1992

HOLE I.D.
MW-3



DEPTH (FEET)	
	PVC SLIP CAP TOP OF PVC ELEVATION 3557.49 FEET
+2 TO 36	2-INCH FLUSH THREADED SCH 40 PVC CASING
36 TO 41	2-INCH FLUSH THREADED 0.020" SLOTTED SCH 40 PVC SCREEN
	FLUSH THREADED SAND POINT
55	TOTAL DEPTH

	DEPTH (FEET)
6" LOCKING STEEL PROTECTOR	
CONCRETE	+0.5 TO 3
GROUT	3 TO 32
STATIC WATER ELEVATION, 3533.26 FEET (11/13/92)	
BENTONITE CHIPS	32 TO 35
COLORADO SILICA SAND 10/20 MESH	35 TO 42
BENTONITE CHIPS	42 TO 55

NOT TO SCALE

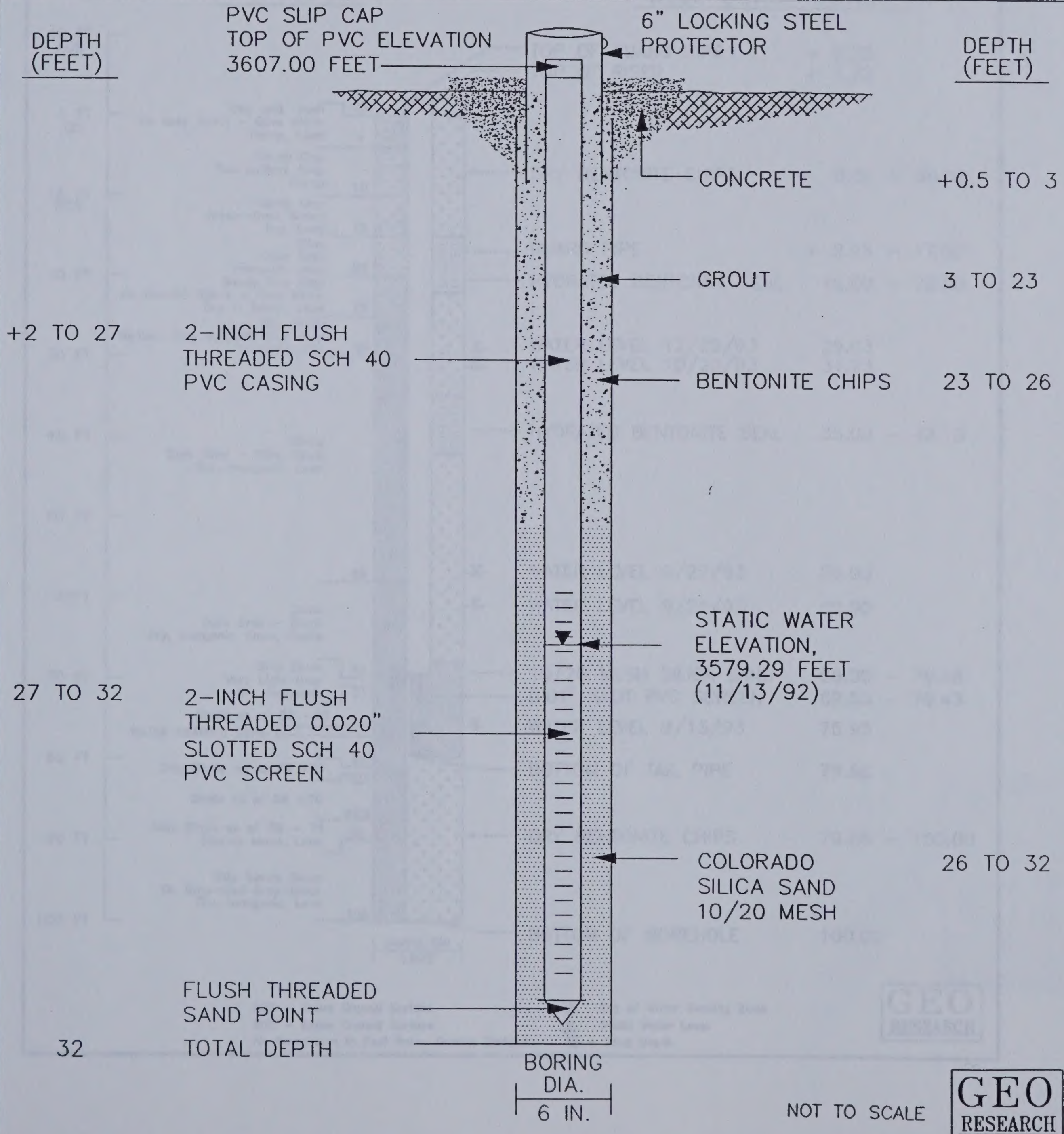
GEO RESEARCH

MONITORING WELL COMPLETION LOG

PROJECT 112035
SITE LAUREL LANDFILL
LOCATION SEE MAP

HYDROGEOLOGIST CURT COOVER
DRILLER PRO PUMP
DATE OCTOBER 28, 1992

HOLE I.D.
MW-4


DEPTH (FEET)
PVC SLIP CAP
TOP OF PVC ELEVATION 3607.00 FEET
6" LOCKING STEEL PROTECTOR
DEPTH (FEET)
CONCRETE
+0.5 TO 3
GROUT
3 TO 23
+2 TO 27
2-INCH FLUSH THREADED SCH 40 PVC CASING
BENTONITE CHIPS
23 TO 26
STATIC WATER ELEVATION, 3579.29 FEET (11/13/92)
27 TO 32
2-INCH FLUSH THREADED 0.020" SLOTTED SCH 40 PVC SCREEN
COLORADO SILICA SAND 10/20 MESH
26 TO 32
FLUSH THREADED SAND POINT
32
TOTAL DEPTH
BORING DIA.
6 IN.

NOT TO SCALE

GEO RESEARCH

LITHOLOGY AND WELL COMPLETION LOG

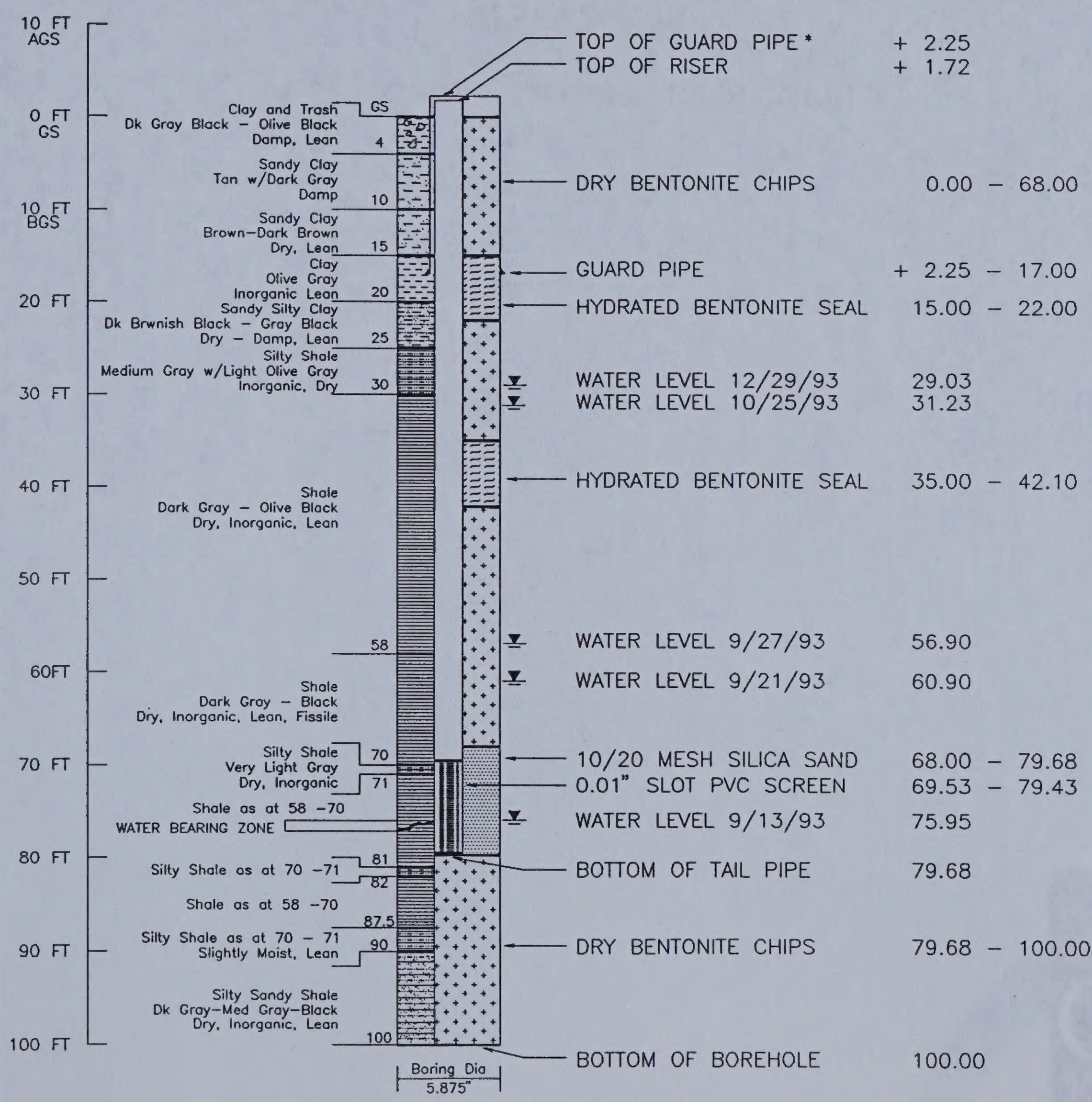
PROJECT NUMBER 112035
SITE LAUREL LANDFILL
LOCATION NW S33 T1S R24E
YELLOWSTONE COUNTY, MT
MP ELEV 3549.93 FT MSL TOGP*

SUPERVISOR J. D. SHAFFER
GEORESEARCH, INC
DRILLER ADT PRO PUMP
DATE DRILLED September 10, 1993
DATE CONSTRUCTED September 10, 1993

BORE HOLE
93MW-2D

LITHOLOGY

WELL CONSTRUCTION



TOP OF GUARD PIPE *	+ 2.25	
TOP OF RISER	+ 1.72	
DRY BENTONITE CHIPS	0.00	– 68.00
GUARD PIPE	+ 2.25	– 17.00
HYDRATED BENTONITE SEAL	15.00	– 22.00
WATER LEVEL 12/29/93	29.03	
WATER LEVEL 10/25/93	31.23	
HYDRATED BENTONITE SEAL	35.00	– 42.10
WATER LEVEL 9/27/93	56.90	
WATER LEVEL 9/21/93	60.90	
10/20 MESH SILICA SAND	68.00	– 79.68
0.01" SLOT PVC SCREEN	69.53	– 79.43
WATER LEVEL 9/13/93	75.95	
BOTTOM OF TAIL PIPE	79.68	
DRY BENTONITE CHIPS	79.68	– 100.00
BOTTOM OF BOREHOLE	100.00	

AGS – Above Ground Surface
BGS – Below Ground Surface
All dimensions in Feet Below Ground Surface

▽ Top of Water Bearing Zone
▼ Static Water Level
TD – Total Depth

GEO RESEARCH

APPENDIX F

DHES COMPLETION LOGS OF WELLS

State of Montana
Department of Health
and Environmental Sciences

Route to: Solid Waste ☐

MONITORING WELL CONSTRUCTION

Facility/Project Name: City of Laurel Landfill

Local Grid Location of Well: 2121.1 ft ☐ N ☒ S 1002.7 ft ☒ E ☐ W

Well Name: MW-1

Facility License: 203

Grid Origin Location: Lat. ____ ____ ____ Long. ____ ____ ____ or St. Plane 624,950 ft N 2,183,550 ft SE

MT Unique Well Number / DHES Well Name:

Type of Well: Water Table Observation Well ☐ 11 Piezometer ☒ 12

Date Well Installed: 10/24/92 (mm dd yy)

Distance Well Is From Waste/Source Boundary: 0 ft

Section Location of Waste/Source: NW/4 Sec 33 T1S R24E ☐ E ☐ W

Well Installed By: (Person's Name and Firm) Curt Coover, GeoResearch, Inc.

Is Well a Point of Standards Application? ☒ Yes ☐ No

Location of Well Relative to Waste/Source: u ☐ Upgradient s ☐ Sidegradient d ☒ Downgradient n ☐ Not Known

Monitoring Well Constructor License Number: MWC-177

A. Protective pipe, top elevation +2.7 ft. ~~MSL~~

B. Well casing, top elevation 3533.79 ft. MSL

C. Land Surface elevation ____.__ ft. MSL

D. Surface seal, bottom ____.__ ft. MSL or 3.__ ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ GW ☐ SP ☐
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☒

13. Sieve analysis attached? ☐ Yes ☒ No

14. Drilling method used: Rotary ☒ Hollow Stem Auger ☐ ____ Other ☐

15. Drilling fluid used: Water ☐ Air ☒ Drilling Mud ☐ None ☐

16. Drilling additives used? ☐ Yes ☒ No

Describe ____

17. Source of water: N/A

E. Bentonite seal, top ____.__ ft. MSL or 3.__ ft.

F. Fine sand, top ____.__ ft. MSL or –.__ ft.

G. Filter pack, top ____.__ ft. MSL or 14.__ ft.

H. Screen joint, top ____.__ ft. MSL or 15.__ ft.

I. Well bottom ____.__ ft. MSL or 20.__ ft.

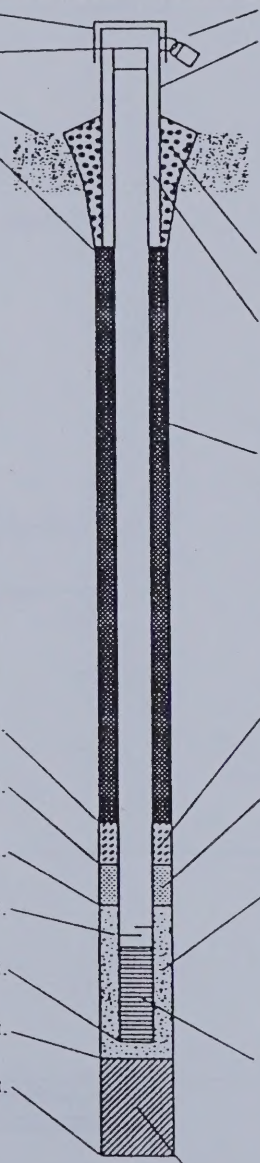
J. Filter pack, bottom ____.__ ft. MSL or 20.__ ft.

K. Borehole bottom ____.__ ft. MSL or 20.__ ft.

L. Borehole, diameter 6.__ in.

M. O.D. well casing 2.4 in.

N. I.D. well casing 2.0 in.



1. Cap and lock? ☒ Yes ☐ No

2. Protective cover pipe:
   a. Inside diameter: 6.0 in.
   b. Length: 5.0 ft.
   c. Material: Steel ☒ ____ Other ☐
   d. Additional protection? ☐ Yes ☒ No
   If yes, describe: ____

3. Surface seal: Bentonite ☐ Concrete ☒ ____ Other ☐

4. Material between well casing and protective pipe: Bentonite ☐ Annular space seal ☐ Concrete Other ☒

5. Annular space seal: a. Granular bentonite ☐
   b. ____ Lbs/gal mud weight . . . Bentonite-sand slurry ☐
   c. ____ Lbs/gal mud weight . . . Bentonite slurry ☐
   d. ____ % bentonite . . . . Bentonite cement grout ☐
   e. 0 Ft^3 volume added for any of the above
   f. How installed: Tremie ☐ Tremie pumped ☐ Gravity ☐

6. Bentonite seal: a. Bentonite granules ☐
   b. ☐ 1/4 in. ☐ 3/8 in. ☐ 1/2. Bentonite pellets ☐
   c. 3/8 inch chips Other ☒

7. Fine sand material: Manufacturer, product name & mesh size
   a. None
   b. Volume added ____ ft^3

8. Filter pack material: Manufacturer, product name & mesh size
   a. Colorado Silica Sand 10x20
   b. Volume added 1 ft^3

9. Well casing: Flush threaded PVC schedule 40 ☒ Flush threaded PVC schedule 80 ☐ ____ Other ☐

10. Screen material: Sch. 40 PVC
   a. Screen type: Factory cut ☒ Continuous slot ☐ ____ Other ☐
   b. Manufacturer: ____
   c. Slot size: 0.020 in.
   d. Slotted length: 4.4 ft.

11. Backfill material: ____ None ☒

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Curt Coover

Firm: GeoResearch, Inc.

State of Montana
Department of Health
and Environmental Sciences

Route to: Solid Waste ☐

MONITORING WELL DEVELOPMENT

Facility/Project Name City of Laurel Landfill	County Name Yellowstone	Well Name MW-1
Facility License Number 203	County Code	MT Unique Well Number / DHES Well Number
Well Installed By: (Person's Name and Firm) Curt Coover - GeoResearch, Inc.		Monitoring Well Constructor License Number MWC - 177

1. Can this well be purged dry? ☐ Yes ☒ No

2. Well development method
   - surged with bailer and bailed ☒
   - surged with bailer and pumped ☐
   - surged with block and bailed ☐
   - surged with block and pumped ☐
   - surged with block, bailed and pumped ☐
   - compressed air ☐
   - bailed only ☐
   - pumped only ☐
   - pumped slowly ☐
   - Other ☐

3. Time spent developing well 20 min.

4. Depth of well (from top of casing) 22. ft.

5. Inside diameter of well 2. in.

6. Volume of water in filter pack and well casing 5.0 gal.

7. Volume of water removed from well 15. gal.

8. Volume of water added (if any) -. gal.

9. Source of water added

10. Analysis performed on water added? ☐ Yes ☐ No
(If yes, attach results)

	Before Development	After Development
11. Depth to Water (from top of well casing) a.	5.375 ft.	5.31 ft.
Date b. (mm dd yy)	10/27/92	11/13/92
Time c.	5:50 ☐ a.m. ☒ p.m.	10:46 ☒ a.m. ☐ p.m.
12. Sediment in well bottom	0. inches	0. inches
13. Water clarity	Clear ☐ Turbid ☒	Clear ☐ Turbid ☒
(Describe)	Muddy at First Last 10 Gal. Turbid	Slighty Turbid

Fill in if drilling fluids were used and well is at solid waste facility:

14. Total suspended solids	. mg/l	. mg/l
15. COD	. mg/l	. mg/l

16. Additional comments on development

Well developed by: (Person's Name and Firm)

Name: Curt Coover

Firm: GeoResearch, Inc.

I hereby certify that the above information is true and correct to the best of my knowledge

Signature:

Print Initials: C A C

Firm: GeoResearch, Inc.

Note: Shaded areas are for DHES use only. See instructions for more information including a list of county codes.

State of Montana
Department of Health
and Environmental Sciences

Route to: Solid Waste ☐

MONITORING WELL CONSTRUCTION

Facility/Project Name: City of Laurel Landfill

Facility License: 203

Type of Well: Water Table Observation Well ☒ 11 Piezometer ☐ 12

Distance Well Is From Waste/Source Boundary: 15 ft

Is Well a Point of Standards Application? ☒ Yes ☐ No

Local Grid Location of Well: 1719.1 ft ☐ N ☒ S 841.9 ft ☒ E ☐ W

Grid Origin Location: Lat. ______ Long. ______ or St. Plane 624,950 ft N 2,183,550 ft E

Section Location of Waste/Source: NW/4 Sec 33 T1S R24E ☐ E ☐ W

Location of Well Relative to Waste/Source: u ☐ Upgradient s ☐ Sidegradient d ☒ Downgradient n ☐ Not Known

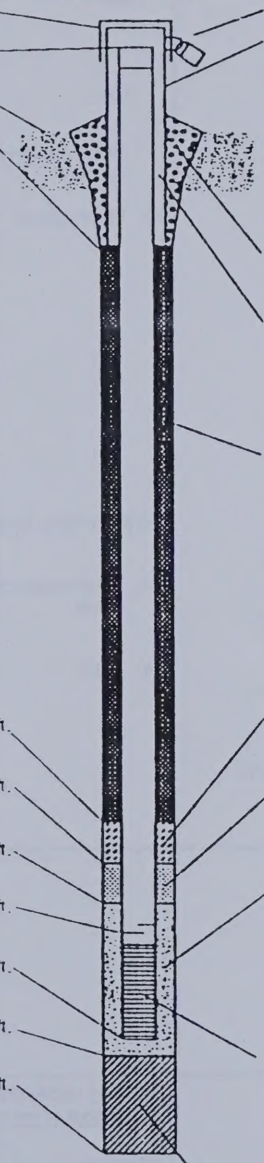
Well Name: MW-2

MT Unique Well Number / DHES Well Name:

Date Well Installed: 10/24/92 (mm dd yy)

Well Installed By: (Person's Name and Firm) Curt Coover, GeoResearch, Inc.

Monitoring Well Constructor License Number: MWC-177



A. Protective pipe, top elevation +2.7 ft. MSL

B. Well casing, top elevation 3550.94 ft. MSL

C. Land Surface elevation ____ ft. MSL

D. Surface seal, bottom ____ ft. MSL or 3. ft.

12. USCS classification of soil near screen: GP ☐ GM ☐ GC ☐ GW ☐ GW ☐ SP ☐ SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐ Bedrock ☒

13. Sieve analysis attached? ☐ Yes ☒ No

14. Drilling method used: Rotary ☒ Hollow Stem Auger ☐ Other ☐

15. Drilling fluid used: Water ☐ Air ☒ Drilling Mud ☐ None ☐

16. Drilling additives used? ☐ Yes ☒ No

Describe ______

17. Source of water: N/A

E. Bentonite seal, top ____ ft. MSL or 3. ft.

F. Fine sand, top ____ ft. MSL or – ft.

G. Filter pack, top ____ ft. MSL or 14. ft.

H. Screen joint, top ____ ft. MSL or 15. ft.

I. Well bottom ____ ft. MSL or 20. ft.

J. Filter pack, bottom ____ ft. MSL or 20. ft.

K. Borehole bottom ____ ft. MSL or 20. ft.

L. Borehole, diameter 6. in.

M. O.D. well casing 2.4 in.

N. I.D. well casing 2.0 in.

1. Cap and lock? ☒ Yes ☐ No

2. Protective cover pipe:
   - a. Inside diameter: 6.0 in.
   - b. Length: 5.0 ft.
   - c. Material: Steel ☒ Other ☐
   - d. Additional protection? ☐ Yes ☒ No
   - If yes, describe: ______

3. Surface seal: Bentonite ☐ Concrete ☒ Other ☐

4. Material between well casing and protective pipe: Bentonite ☐ Annular space seal ☐ Concrete Other ☒

5. Annular space seal:
   - a. Granular bentonite ☐
   - b. ____ Lbs/gal mud weight . . . Bentonite-sand slurry ☐
   - c. ____ Lbs/gal mud weight . . . Bentonite slurry ☐
   - d. ____ % bentonite . . . . Bentonite cement grout ☐
   - e. None Ft^3 volume added for any of the above
   - f. How installed: Tremie ☐ Tremie pumped ☐ Gravity ☐

6. Bentonite seal:
   - a. Bentonite granules ☐
   - b. ☐ 1/4 in. ☐ 3/8 in. ☐ 1/2. Bentonite pellets ☐
   - c. 3/8 inch chips Other ☒

7. Fine sand material: Manufacturer, product name & mesh size
   - a. None
   - b. Volume added ______ ft^3

8. Filter pack material: Manufacturer, product name & mesh size
   - a. Colorado Silica Sand 10x20
   - b. Volume added 1 ft^3

9. Well casing: Flush threaded PVC schedule 40 ☒ Flush threaded PVC schedule 80 ☐ Other ☐

10. Screen material: Sch. 40 PVC
   - a. Screen type: Factory cut ☒ Continuous slot ☐ Other ☐
   - b. Manufacturer: ______
   - c. Slot size: 0.020 in.
   - d. Slotted length: 4.4 ft.

11. Backfill material: None ☒

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature

Firm: GeoResearch, Inc.

State of Montana
Department of Health
and Environmental Sciences

Route to: Solid Waste ☐

MONITORING WELL DEVELOPMENT

Facility/Project Name City of Laurel Landfill	County Name Yellowstone	Well Name MW-2
Facility License Number 203	County Code	MT Unique Well Number / DHES Well Number
Well Installed By: (Person's Name and Firm) Curt Coover - GeoResearch, Inc.		Monitoring Well Constructor License Number MWC - 177

1. Can this well be purged dry? ☒ Yes ☐ No

2. Well development method
   - surged with bailer and bailed ☒
   - surged with bailer and pumped ☐
   - surged with block and bailed ☐
   - surged with block and pumped ☐
   - surged with block, bailed and pumped ☐
   - compressed air ☐
   - bailed only ☐
   - pumped only ☐
   - pumped slowly ☐
   - Other ☐

3. Time spent developing well 15 min.

4. Depth of well (from top of casing) 22. ft.

5. Inside diameter of well 2. in.

6. Volume of water in filter pack and well casing 2.1 gal.

7. Volume of water removed from well 3. gal.

8. Volume of water added (if any) –. gal.

9. Source of water added

10. Analysis performed on water added? ☐ Yes ☐ No
(If yes, attach results)

	Before Development	After Development
11. Depth to Water (from top of well casing)	a. 18.17 ft.	18.26 ft.
Date	b. 10/27/92 mm dd yy	11/13/92 mm dd yy
Time	c. 6:10 ☐ a.m. ☒ p.m.	10:41 ☒ a.m. ☐ p.m.
12. Sediment in well bottom	0. inches	0. inches
13. Water clarity	Clear ☐ Turbid ☒ (Describe) Muddy	Clear ☐ Turbid ☒ (Describe) Somewhat Turbid

Fill in if drilling fluids were used and well is at solid waste facility:

14. Total suspended solids	. mg/l	. mg/l
15. COD	. mg/l	. mg/l

16. Additional comments on development

Well developed by: (Person's Name and Firm)

Name: Curt Coover

Firm: GeoResearch, Inc.

I hereby certify that the above information is true and correct to the best of my knowledge

Signature:

Print Initials: C A C

Firm: GeoResearch, Inc.

Note: Shaded areas are for DHES use only. See instructions for more information including a list of county codes.

State of Montana
Department of Health
and Environmental Sciences

Route to: Solid Waste ☐

MONITORING WELL CONSTRUCTION

Facility/Project Name: City of Laurel Landfill

Local Grid Location of Well: 2121.1 ft. ☐ N ☒ S 493.2 ft. ☒ E ☐ W

Well Name: MW-3

Facility License: 203

Grid Origin Location: Lat. ______ Long. ______ or St. Plane 624,950 ft. N 2,183550 ft. 85E

MT Unique Well Number:

OHES Well Name:

Type of Well: Water Table Observation Well ☐ 11 Piezometer ☒ 12

Date Well Installed: 10/24/92 (mm dd yy)

Distance Well Is From Waste/Source Boundary: 10 ft.

Section Location of Waste/Source: NW/4 Sec 33 T1S R24E ☐ E ☐ W

Well Installed By: (Person's Name and Firm) Curt Coover, GeoResearch, Inc.

Is Well a Point of Standards Application? ☒ Yes ☐ No

Location of Well Relative to Waste/Source: u ☐ Upgradient s ☐ Sidegradient d ☒ Downgradient n ☐ Not Known

Monitoring Well Constructor License Number: MWC-177

A. Protective pipe, top elevation +2.7 ft. MSL

B. Well casing, top elevation 3557.49 ft. MSL

C. Land Surface elevation ____.__ ft. MSL

D. Surface seal, bottom ____.__ ft. MSL or 3 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ GW ☐ SP ☐
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☒

13. Sieve analysis attached? ☐ Yes ☒ No

14. Drilling method used: Rotary ☒ Hollow Stem Auger ☐ Other ☐ ______

15. Drilling fluid used: Water ☐ Air ☒ Drilling Mud ☐ None ☐

16. Drilling additives used? ☐ Yes ☒ No

Describe ______

17. Source of water: N/A

E. Bentonite seal, top ____.__ ft. MSL or 32 ft.

F. Fine sand, top ____.__ ft. MSL or - ft.

G. Filter pack, top ____.__ ft. MSL or 35 ft.

H. Screen joint, top ____.__ ft. MSL or 36 ft.

I. Well bottom ____.__ ft. MSL or 41 ft.

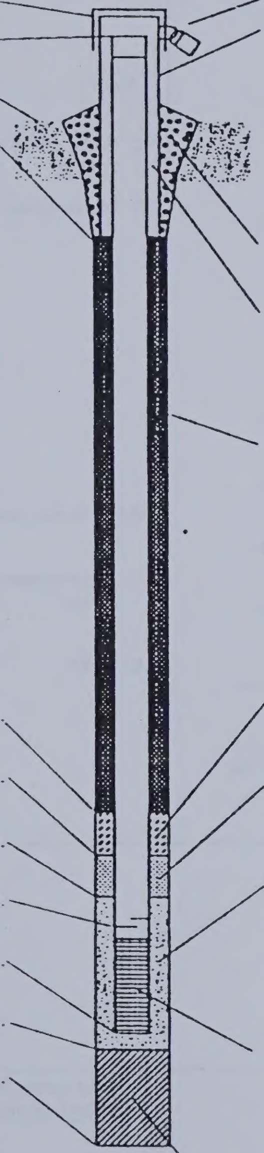
J. Filter pack, bottom ____.__ ft. MSL or 42 ft.

K. Borehole bottom ____.__ ft. MSL or 55 ft.

L. Borehole, diameter 6 in.

M. O.D. well casing 2.4 in.

N. I.D. well casing 2.0 in.



1. Cap and lock? ☒ Yes ☐ No
2. Protective cover pipe:
   a. Inside diameter: 6.0 in.
   b. Length: 5.0 ft.
   c. Material: Steel ☒ Other ☐ ______
   d. Additional protection? ☐ Yes ☒ No
   If yes, describe: ______
3. Surface seal: Bentonite ☐ Concrete ☒ Other ☐ ______
4. Material between well casing and protective pipe: Bentonite ☐ Annular space seal ☐ Concrete Other ☒
5. Annular space seal: a. Granular bentonite ☐
   b. ____ Lbs/gal mud weight . . . Bentonite-sand slurry ☐
   c. ____ Lbs/gal mud weight . . . Bentonite slurry ☐
   d. 3 % bentonite . . . . Bentonite cement grout ☒
   e. 5 Ft^3 volume added for any of the above
   f. How installed: Tremie ☐ Tremie pumped ☒ Gravity ☐
6. Bentonite seal: a. Bentonite granules ☐
   b. ☐ 1/4 in. ☐ 3/8 in. ☐ 1/2. Bentonite pellets ☐
   c. 3/8 inch chips Other ☒
7. Fine sand material: Manufacturer, product name & mesh size
   a. None
   b. Volume added ______ ft^3
8. Filter pack material: Manufacturer, product name & mesh size
   a. Colorado Silica Sand 10x20
   b. Volume added 1.1 ft^3
9. Well casing: Flush threaded PVC schedule 40 ☒ Flush threaded PVC schedule 80 ☐ Other ☐ ______
10. Screen material: Sch. 40 PVC
   a. Screen type: Factory cut ☒ Continuous slot ☐ Other ☐ ______
   b. Manufacturer: ______
   c. Slot size: 0020 in.
   d. Slotted length: 4.4 ft.
11. Backfill material: 3/8 inch Bentonite Chips None ☐

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Curt Coover

Firm: GeoResearch, Inc.

State of Montana
Department of Health
and Environmental Sciences

Route to: Solid Waste ☐

MONITORING WELL DEVELOPMENT

Facility/Project Name: City of Laurel Landfill

County Name: Yellowstone

Well Name: MW-3

Facility License Number: 203

County Code:

MT Unique Well Number:

DHES Well Number:

Well Installed By: (Person's Name and Firm) Curt Coover - GeoResearch, Inc.

Monitoring Well Constructor License Number: MWC - 177

1. Can this well be purged dry? ☒ Yes ☐ No

2. Well development method
   - surged with bailer and bailed ☒
   - surged with bailer and pumped ☐
   - surged with block and bailed ☐
   - surged with block and pumped ☐
   - surged with block, bailed and pumped ☐
   - compressed air ☐
   - bailed only ☐
   - pumped only ☐
   - pumped slowly ☐
   - Other ________ ☐

3. Time spent developing well 10 min.

4. Depth of well (from top of casing) 44. ft.

5. Inside diameter of well 2. in.

6. Volume of water in filter pack and well casing 4.3 gal.

7. Volume of water removed from well 3.5 gal.

8. Volume of water added (if any) – . gal.

9. Source of water added ________

10. Analysis performed on water added? ☐ Yes ☐ No
(If yes, attach results)

	Before Development	After Development
11. Depth to Water (from top of well casing)	a. 33.31 ft.	24.23 ft.
Date	b. 10/27/92 (mm dd yy)	11/13/92 (mm dd yy)
Time	c. 5:40 ☐ a.m. ☒ p.m.	10:36 ☒ a.m. ☐ p.m.
12. Sediment in well bottom	0. inches	0. inches
13. Water clarity	Clear ☐ Turbid ☒ (Describe) Muddy	Clear ☐ Turbid ☒ (Describe) Somewhat Turbid

Fill in if drilling fluids were used and well is at solid waste facility:

14. Total suspended solids	. mg/l	. mg/l
15. COD	. mg/l	. mg/l

16. Additional comments on development

Well developed by: (Person's Name and Firm)

Name: Curt Coover

Firm: GeoResearch, Inc.

I hereby certify that the above information is true and correct to the best of my knowledge

Signature:

Print Initials: C A C

Firm: GeoResearch, Inc.

Note: Shaded areas are for DHES use only. See instructions for more information including a list of county codes.

State of Montana
Department of Health
and Environmental Sciences

Route to: Solid Waste ☐

MONITORING WELL CONSTRUCTION

Facility/Project Name: City of Laurel Landfill

Local Grid Location of Well: 1228.5 ft. ☐ N ☒ S   23.7 ft. ☐ E ☒ W

Well Name: MW-4

Facility License: 203

Grid Origin Location: Lat. ______ Long. ______ or

MT Unique Well Number   DHES Well Name

St. Plane 624,950 ft. N 2,183550 ft. 8E

Type of Well: Water Table Observation Well ☒ 11   Piezometer ☐ 12

Date Well Installed: 10/24/92 (mm dd yy)

Section Location of Waste/Source: NW/4 Sec 33 T1S R24E ☐ E ☐ W

Distance Well Is From Waste/Source Boundary ______ ft.

Well Installed By: (Person's Name and Firm) Curt Coover, GeoResearch, Inc.

Location of Well Relative to Waste/Source:
u ☒ Upgradient   s ☐ Sidegradient
d ☐ Downgradient   n ☐ Not Known

Is Well a Point of Standards Application? ☒ Yes ☐ No

Monitoring Well Constructor License Number: MWC-177

A. Protective pipe, top elevation +2.7 ft. MSL

B. Well casing, top elevation 3607.00 ft. MSL

C. Land Surface elevation ______ ft. MSL

D. Surface seal, bottom ______ ft. MSL or 3. ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ GW ☐ SP ☐
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☒

13. Sieve analysis attached? ☐ Yes ☒ No

14. Drilling method used: Rotary ☒
Hollow Stem Auger ☐
Other ☐ ______

15. Drilling fluid used: Water ☐ Air ☒
Drilling Mud ☐ None ☐

16. Drilling additives used? ☐ Yes ☒ No

Describe ______

17. Source of water: N/A

E. Bentonite seal, top ______ ft. MSL or 23. ft.

F. Fine sand, top ______ ft. MSL or –. ft.

G. Filter pack, top ______ ft. MSL or 26. ft.

H. Screen joint, top ______ ft. MSL or 27. ft.

I. Well bottom ______ ft. MSL or 32. ft.

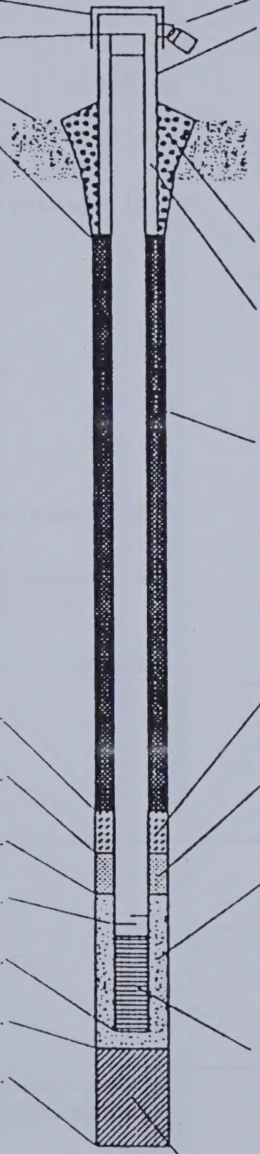
J. Filter pack, bottom ______ ft. MSL or 32. ft.

K. Borehole bottom ______ ft. MSL or 32. ft.

L. Borehole, diameter 6. in.

M. O.D. well casing 2.4 in.

N. I.D. well casing 2.0 in.



1. Cap and lock? ☒ Yes ☐ No

2. Protective cover pipe:
   a. Inside diameter: 6.0 in.
   b. Length: 5.0 ft.
   c. Material: Steel ☒
      ______ Other ☐
   d. Additional protection? ☐ Yes ☒ No
      If yes, describe: ______

3. Surface seal: Bentonite ☐
   Concrete ☒
   ______ Other ☐

4. Material between well casing and protective pipe:
   Bentonite ☐
   Annular space seal ☐
   Concrete Other ☒

5. Annular space seal: a. Granular bentonite ☐
   b. ______ Lbs/gal mud weight . . . Bentonite-sand slurry ☐
   c. ______ Lbs/gal mud weight . . . Bentonite slurry ☐
   d. 3 % bentonite . . . . . . Bentonite cement grout ☒
   e. 3.2 Ft^3 volume added for any of the above
   f. How installed: Tremie ☐
      Tremie pumped ☒
      Gravity ☐

6. Bentonite seal: a. Bentonite granules ☐
   b. ☐ 1/4 in. ☐ 3/8 in. ☐ 1/2. Bentonite pellets ☐
   c. 3/8 inch chips Other ☒

7. Fine sand material: Manufacturer, product name & mesh size
   a. None
   b. Volume added ______ ft^3

8. Filter pack material: Manufacturer, product name & mesh size
   a. Colorado Silica Sand 10x20
   b. Volume added 1 ft^3

9. Well casing: Flush threaded PVC schedule 40 ☒
   Flush threaded PVC schedule 80 ☐
   ______ Other ☐

10. Screen material: Sch. 40 PVC
   a. Screen type: Factory cut ☒
      Continuous slot ☐
      ______ Other ☐
   b. Manufacturer: ______
   c. Slot size: 0.020 in.
   d. Slotted length: 4.4 ft.

11. Backfill material: ______ None ☒

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Curt Coover

Firm: GeoResearch, Inc.

State of Montana
Department of Health
and Environmental Sciences

Route to: Solid Waste ☐

MONITORING WELL DEVELOPMENT

Facility/Project Name City of Laurel Landfill	County Name Yellowstone	Well Name MW-4	
Facility License Number 203	County Code	MT Unique Well Number	DHES Well Number
Well Installed By: (Person's Name and Firm) Curt Coover - GeoResearch, Inc.	Monitoring Well Constructor License Number MWC - 177		

1. Can this well be purged dry? ☒ Yes ☐ No

2. Well development method
- surged with bailer and bailed ☒
- surged with bailer and pumped ☐
- surged with block and bailed ☐
- surged with block and pumped ☐
- surged with block, bailed and pumped ☐
- compressed air ☐
- bailed only ☐
- pumped only ☐
- pumped slowly ☐
- Other ______ ☐

3. Time spent developing well 13 min.

4. Depth of well (from top of casing) 34. ft.

5. Inside diameter of well 2. in.

6. Volume of water in filter pack and well casing ___.__ gal.

7. Volume of water removed from well 2. gal.

8. Volume of water added (if any) -. gal.

9. Source of water added ______

10. Analysis performed on water added? ☐ Yes ☐ No
(If yes, attach results)

	Before Development	After Development
11. Depth to Water (from top of well casing)	a. 27.79 ft.	27.71 ft.
Date	b. 10/27/92 (mm dd yy)	11/13/92 (mm dd yy)
Time	c. 5:27 ☐ a.m. ☒ p.m.	10:25 ☒ a.m. ☐ p.m.
12. Sediment in well bottom	0. inches	0. inches
13. Water clarity	Clear ☐ Turbid ☒ (Describe) Muddy	Clear ☐ Turbid ☒ (Describe) Somewhat Turbid

Fill in if drilling fluids were used and well is at solid waste facility:

14. Total suspended solids	____.__ mg/l	____.__ mg/l
15. COD	____.__ mg/l	____.__ mg/l

16. Additional comments on development

Well developed by: (Person's Name and Firm)

Name: Curt Coover

Firm: GeoResearch, Inc.

I hereby certify that the above information is true and correct to the best of my knowledge

Signature:

Print Initials: C A C

Firm: GeoResearch, Inc.

Note: Shaded areas are for DHES use only. See instructions for more information including a list of county codes.

State of Montana
Department of Health
and Environmental Sciences

Route to: Solid Waste ☒

MONITORING WELL CONSTRUCTION

Facility/Project Name: City of Laurel Landfill

Facility License: 203

Type of Well: Water Table Observation Well ☒ 11 / Piezometer ☐ 12

Distance Well Is From Waste/Source Boundary: 10 ft

Is Well a Point of Standards Application? ☐ Yes ☐ No

Local Grid Location of Well: 1745.9 ft ☐ N ☒ S 841.9 ft ☒ E ☐ W

Grid Origin Location: Lat. ___ Long. ___ or St. Plane 624,950 ft N 2,183,550 ft E

Section Location of Waste/Source: NW¼ Sec 33 T1S R24E ☐ E ☐ W

Location of Well Relative to Waste/Source: u ☐ Upgradient s ☒ Sidegradient d ☐ Downgradient n ☐ Not Known

Well Name: 93MD-2D

MT Unique Well Number / DHES Well Name:

Date Well Installed: 09/10/93 (mm dd yy)

Well Installed By: (Person's Name and Firm) J. Wayne Jewett, ADT, Inc.

Monitoring Well Constructor License Number: MWC 217

A. Protective pipe, top elevation 3549.93 ft. MSL

B. Well casing, top elevation 3549.40 ft. MSL

C. Land Surface elevation 3547.64 ft. MSL

D. Surface seal, bottom ___ ft. MSL or 00.0 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ GW ☐ SP ☐
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☒

13. Sieve analysis attached? ☐ Yes ☒ No

14. Drilling method used: Air Rotary ☒ Hollow Stem Auger ☐ --- Other ☐

15. Drilling fluid used: Water ☐ Air ☒ Drilling Mud ☐ None ☐

16. Drilling additives used? ☐ Yes ☒ No

Describe ---

17. Source of water: N/A

E. Bentonite seal, top ___ ft. MSL or 15.0 and 35.0 ft.

F. Fine sand, top ___ ft. MSL or ___ ft.

G. Filter pack, top ___ ft. MSL or 68.0 ft.

H. Screen joint, top ___ ft. MSL or 69.5 ft.

I. Well bottom ___ ft. MSL or 79.7 ft.

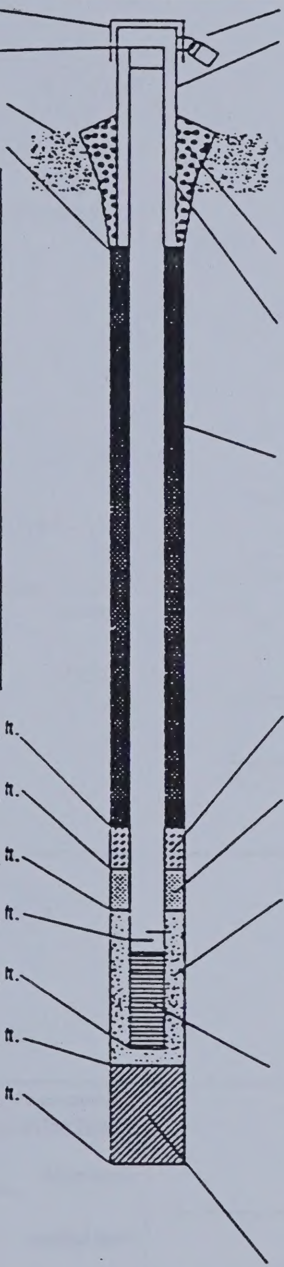
J. Filter pack, bottom ___ ft. MSL or 79.7 ft.

K. Borehole bottom ___ ft. MSL or 100.0 ft.

L. Borehole, diameter 5.9 in.

M. O.D. well casing 2.4 in.

N. I.D. well casing 2.0 in.



1. Cap and lock? ☒ Yes ☐ No

2. Protective cover pipe:
   a. Inside diameter: 6.0 in.
   b. Length: 19.3 ft.
   c. Material: --- Steel ☒ Other ☐
   d. Additional protection? ☐ Yes ☒ No
   If yes, describe:

3. Surface seal: Bentonite ☒ Concrete ☐ --- Other ☐

4. Material between well casing and protective pipe: Bentonite ☒ Annular space seal ☐ --- Other ☐

5. Annular space seal: a. ~~Granular~~ bentonite ☒ chips
   b. ___ Lbs/gal mud weight . . . Bentonite-sand slurry ☐
   c. ___ Lbs/gal mud weight . . . Bentonite slurry ☐
   d. ___ % bentonite . . . . Bentonite cement grout ☐
   e. ___ Ft^3 volume added for any of the above
   f. How installed: Tremie ☐ Tremie pumped ☐ Gravity ☒

6. Bentonite seal: a. Bentonite granules ☐
   b. ☐ 1/4 in. ☒ 3/8 in. ☐ 1/2 Bentonite pellets ☒
   c. pellets hydrated w/5 gal water Other ☒

7. Fine sand material: Manufacturer, product name & mesh size
   a. None
   b. Volume added ___ ft^3

8. Filter pack material: Manufacturer, product name & mesh size
   a. Colorado Silica Sand 10-20 mesh
   b. Volume added 2 ft^3

9. Well casing: Flush threaded PVC schedule 40 ☒ Flush threaded PVC schedule 80 ☐ Other ☐

10. Screen material: Schedule 40 PVC
   a. Screen type: Factory cut ☒ Continuous slot ☐ --- Other ☐
   b. Manufacturer:
   c. Slot size: 0.010 in.
   d. Slotted length: 9.9 ft.

11. Backfill material: bentonite chips None ☐

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: James D. Sheffer

Firm: GeoResearch, Inc.

State of Montana
Department of Health
and Environmental Sciences

Route to: Solid Waste ☒

MONITORING WELL DEVELOPMENT

Facility/Project Name: City of Laurel Landfill
County Name: Yellowstone County
Well Name: 93MW-2D
Facility License Number: 203
County Code: __
MT Unique Well Number: ______
DHES Well Number: ______
Well Installed By: (Person's Name and Firm) Wayne Jewett, ADT, Inc.
Monitoring Well Constructor License Number: MWC-217

1. Can this well be purged dry? ☒ Yes ☐ No

2. Well development method
   - surged with bailer and bailed ☒
   - surged with bailer and pumped ☐
   - surged with block and bailed ☐
   - surged with block and pumped ☐
   - surged with block, bailed and pumped ☐
   - compressed air ☐
   - bailed only ☐
   - pumped only ☐
   - pumped slowly ☐
   - Other ______ ☐

3. Time spent developing well ______ min.

4. Depth of well (from top of casing) 81.4 ft.

5. Inside diameter of well 2.0 in.

6. Volume of water in filter pack and well casing 5.3 gal.

7. Volume of water removed from well 6.5 gal.

8. Volume of water added (if any) ____.__ gal.

9. Source of water added ______

10. Analysis performed on water added? ☐ Yes ☐ No
(If yes, attach results)

	Before Development	After Development
11. Depth to Water (from top of well casing) a.	62.63 ft.	dry ft.
Date b.	09/13/93 (mm dd yy)	09/13/93 (mm dd yy)
Time c.	17:05 ☐ a.m. ☐ p.m.	17:37 ☐ a.m. ☐ p.m.
12. Sediment in well bottom	0. inches	0. inches
13. Water clarity	Clear ☒ Turbid ☐	Clear ☐ Turbid ☒
(Describe)	first bail clear, then murky	murky grey/brown

Fill in if drilling fluids were used and well is at solid waste facility:

14. Total suspended solids	____.__ mg/l	____.__ mg/l
15. COD	____.__ mg/l	____.__ mg/l

16. Additional comments on development

Well developed by: (Person's Name and Firm)
Name: Margaret Hofacker
Firm: GeoResearch, Inc.

I hereby certify that the above information is true and correct to the best of my knowledge
Signature: Margaret M. Hofacker
Print Initials: M M H
Firm: GeoResearch, Inc.

Note: Shaded areas are for DHES use only. See instructions for more information including a list of county codes.

APPENDIX G

LABORATORY REPORTS

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.

P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48610
DATE: 12/08/92 da

WATER ANALYSIS

Project No. 112035
Laurel Landfill
MW-1
Sampled 11/14/92 @ 0935
Submitted 11/16/92

Constituent	mg/l (ppm)	
Potassium	41	
Sodium	4570	
Calcium	413	
Magnesium	4040	
Sulfate	25000	
Chloride	191	
Carbonate	0	
Bicarbonate	1050	
Total Dissolved Solids @ 180° C	38700	
Total Alkalinity as $CaCO_3$	864	
Specific Conductance @ 25° C	26900	µmhos/cm
pH	6.8	s.u.
Nitrate as N	<0.05	
Ammonia as N	0.3	
Chemical Oxygen Demand	39	
Total Suspended Solids	1050	
Total Cyanide	<0.005	
Dissolved Metals		
Arsenic	0.016	
Barium	<0.1	
Cadmium	<0.01*	
Chromium	<0.1*	
Iron	<0.3*	
Lead	<0.1*	
Manganese	11.2	
Mercury	<0.005*	
Selenium	<0.005	
Silver	<0.06*	

*Detection limit raised due to sample matrix interferences.

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FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48612
DATE: 12/08/92 da

WATER ANALYSIS

Project No. 112035
Laurel Landfill
MW-5
Sampled 11/14/92 @ 0940
Submitted 11/16/92

Constituent	mg/l (ppm)	
Potassium	39	
Sodium	4580	
Calcium	415	
Magnesium	4000	
Sulfate	25100	
Chloride	193	
Carbonate	0	
Bicarbonate	1060	
Total Dissolved Solids @ 180° C	39000	
Total Alkalinity as $CaCO_3$	868	
Specific Conductance @ 25° C	27000	µmhos/cm
pH	6.9	s.u.
Nitrate as N	<0.05	
Ammonia as N	0.4	
Chemical Oxygen Demand	41	
Total Suspended Solids	720	
Total Cyanide	<0.005	

Dissolved Metals	
Arsenic	<0.005
Barium	<0.1
Cadmium	<0.01*
Chromium	<0.1*
Iron	<0.3*
Lead	<0.1*
Manganese	10.5
Mercury	<0.005*
Selenium	<0.005
Silver	<0.06*

*Detection limit raised due to sample matrix interferences.

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LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48610 dup
DATE: 12/08/92 da

QUALITY ASSURANCE-DUPLICATE ANALYSIS

Project No. 112035
Laurel Landfill
MW-1
Sampled 11/14/92 @ 0935
Submitted 11/16/92

Constituent	mg/l (ppm)	
Potassium	38	
Sodium	4480	
Calcium	411	
Magnesium	3990	
Sulfate	25000	
Chloride	188	
Carbonate	0	
Bicarbonate	1060	
Total Dissolved Solids @ 180° C	38600	
Total Alkalinity as $CaCO_3$	870	
Specific Conductance @ 25° C	27000	µmhos/cm
pH	6.8	s.u.
Nitrate as N	<0.05	
Ammonia as N	0.3	
Chemical Oxygen Demand	40	
Total Suspended Solids	1050	
Total Cyanide	<0.005	
Dissolved Metals		
Arsenic	0.014	
Barium	<0.1	
Cadmium	<0.01*	
Chromium	<0.1*	
Iron	<0.3*	
Lead	<0.1*	
Manganese	11.3	
Mercury	<0.005*	
Selenium	<0.005	
Silver	<0.06*	

*Detection limit raised due to sample matrix interferences.

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LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48611
DATE: 12/08/92 da

WATER ANALYSIS

Project No. 112035
Laurel Landfill
MW-2
Sampled 11/13/92 @ 1515
Submitted 11/16/92

Constituent	mg/l (ppm)	
Potassium	33	
Sodium	2300	
Calcium	404	
Magnesium	2890	
Sulfate	16400	
Chloride	199	
Carbonate	0	
Bicarbonate	602	
Total Dissolved Solids @ 180° C	24400	
Total Alkalinity as $CaCO_3$	494	
Specific Conductance @ 25° C	18800	µmhos/cm
pH	7.0	s.u.
Nitrate as N	51.5	
Ammonia as N	<0.1	
Chemical Oxygen Demand	53	
Total Suspended Solids	3430	
Total Cyanide	<0.005	
Dissolved Metals		
Arsenic	<0.05*	
Barium	<0.1	
Cadmium	0.024	
Chromium	<0.1*	
Iron	<0.3*	
Lead	<0.1*	
Manganese	0.13	
Mercury	<0.005*	
Selenium	0.89	
Silver	<0.06*	

*Detection limit raised due to sample matrix interferences.

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LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48609
DATE: 12/08/92 da

WATER ANALYSIS

Project No. 112035
Laurel Landfill
MW-3
Sampled 11/13/92 @ 1340
Submitted 11/16/92

Constituent	mg/l (ppm)	
Potassium	28	
Sodium	10500	
Calcium	364	
Magnesium	715	
Sulfate	23900	
Chloride	354	
Carbonate	0	
Bicarbonate	1460	
Total Dissolved Solids @ 180° C	36100	
Total Alkalinity as $CaCO_3$	1200	
Specific Conductance @ 25° C	33800	µmhos/cm
pH	7.4	s.u.
Nitrate as N	0.14	
Ammonia as N	4.5	
Chemical Oxygen Demand	10	
Total Suspended Solids	1900	
Total Cyanide	<0.005	

Dissolved Metals	
Arsenic	0.005
Barium	<0.1
Cadmium	<0.01*
Chromium	<0.1*
Iron	1.11
Lead	<0.1*
Manganese	0.32
Mercury	<0.005*
Selenium	<0.005
Silver	0.404

*Detection limit raised due to sample matrix interferences.

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LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48608
DATE: 12/08/92 da

WATER ANALYSIS

Project No. 112035
Laurel Landfill
MW-4
Sampled 11/13/92 @ 1220
Submitted 11/16/92

Constituent	mg/l (ppm)	
Potassium	27	
Sodium	954	
Calcium	421	
Magnesium	850	
Sulfate	5530	
Chloride	96	
Carbonate	0	
Bicarbonate	711	
Total Dissolved Solids @ 180° C	8830	
Total Alkalinity as $CaCO_3$	583	
Specific Conductance @ 25° C	8210	µmhos/cm
pH	7.2	s.u.
Nitrate as N	1.29	
Ammonia as N	0.3	
Chemical Oxygen Demand	20	
Total Suspended Solids	2820	
Total Cyanide	<0.005	
Dissolved Metals		
Arsenic	<0.005	
Barium	<0.1	
Cadmium	<0.001	
Chromium	<0.01	
Iron	<0.3*	
Lead	<0.1*	
Manganese	1.00	
Mercury	<0.005*	
Selenium	0.18	
Silver	<0.005	

*Detection limit raised due to sample matrix interferences.

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LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48613
DATE: 12/08/92 da

WATER ANALYSIS

Project No. 112035
Laurel Landfill
MW-6
Sampled 11/14/92 @ 1110
Submitted 11/16/92

Constituent	mg/l (ppm)	
Potassium	<1	
Sodium	<1	
Calcium	<1	
Magnesium	<1	
Sulfate	2	
Chloride	<1	
Carbonate	0	
Bicarbonate	2	
Total Dissolved Solids @ 180° C	6	
Total Alkalinity as $CaCO_3$	2	
Specific Conductance @ 25° C	7	µmhos/cm
pH	5.8	s.u.
Nitrate as N	<0.05	
Ammonia as N	<0.1	
Chemical Oxygen Demand	2	
Total Suspended Solids	<1	
Total Cyanide	<0.005	
Dissolved Metals		
Arsenic	<0.005	
Barium	<0.1	
Cadmium	<0.001	
Chromium	<0.01	
Iron	<0.03	
Lead	<0.01	
Manganese	<0.02	
Mercury	<0.001	
Selenium	<0.005	
Silver	<0.005	

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LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48611 spi
DATE: 12/08/92 da

QUALITY ASSURANCE-SPIKED ANALYSIS

Project No. 112035
Laurel Landfill
MW-2
Sampled 11/13/92 @ 1515
Submitted 11/16/92

Constituent	% Recovery	
Potassium	100	
Sodium	99	
Calcium	100	
Magnesium	100	
Sulfate	100	
Chloride	99	
Carbonate	N/A	
Bicarbonate	N/A	
Total Dissolved Solids @ 180° C	N/A	
Total Alkalinity as $CaCO_3$	N/A	
Specific Conductance @ 25° C	N/A	µmhos/cm
pH	N/A	s.u.
Nitrate as N	96	
Ammonia as N	87	
Chemical Oxygen Demand	101	
Total Suspended Solids	N/A	
Total Cyanide	94	
Dissolved Metals		
Arsenic	81	*
Barium	107	
Cadmium	98	
Chromium	*	
Iron	*	
Lead	*	
Manganese	96	
Mercury	98	
Selenium	*	
Silver	*	

*Unable to get spike recovery due to matrix interferences.

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LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48610
DATE: 12/03/92 ag

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill, MW-1
Sampled 11/14/92 @ 0935
Submitted 11/16/92

Constituent	µg/l	Constituent	µg/l
Benzene	<1.0	1,1-Dichloroethane	<1.0
Bromochloromethane	<1.0	1,2-Dichloroethane	<1.0
Bromodichloromethane	<1.0	Iodomethane	<1.0
cis-1,3-Dichloropropene	<1.0	Methylene chloride	<1.0
trans-1,3-Dichloropropene	<1.0	1,1-Dichloroethene	<1.0
1,4-Difluorobenzene	<1.0	trans-1,2-Dichloroethene	<1.0
Ethylbenzene	<1.0	Styrene	<1.0
Ethyl methacrylate	<1.0	1,1,2,2-Tetrachloroethane	<1.0
4-Bromofluorobenzene	<10	Toluene	<1.0
Bromoform	<1.0	1,1,1-Trichloroethane	<1.0
Bromomethane	<1.0	1,1,2-Trichloroethane	<1.0
Carbon tetrachloride	<1.0	Trichloroethene	<1.0
Chlorobenzene	<1.0	Trichlorofluoromethane	<1.0
Dibromochloromethane	<1.0	1,2,3-Trichloropropane	<1.0
Chloroethane	<1.0	Vinyl acetate	<20
2-Chloroethyl vinyl ether	<1.0	Vinyl chloride	<1.0
Chloroform	<1.0	Xylenes	<1.0
Chloromethane	<1.0	Tetrachloroethene	<1.0
Dibromomethane	<1.0		
Dichlorodifluoromethane	<1.0		

NOTE: Analysis done by EPA method 8240.

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LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48611
DATE: 12/03/92 ag

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill, MW-2
Sampled 11/13/92 @ 1515
Submitted 11/16/92

Constituent	µg/l	Constituent	µg/l
Benzene	<1.0	1,1-Dichloroethane	<1.0
Bromochloromethane	<1.0	1,2-Dichloroethane	<1.0
Bromodichloromethane	<1.0	Iodomethane	<1.0
cis-1,3-Dichloropropene	<1.0	Methylene chloride	2.0
trans-1,3-Dichloropropene	<1.0	1,1-Dichloroethene	<1.0
1,4-Difluorobenzene	<1.0	trans-1,2-Dichloroethene	<1.0
Ethylbenzene	<1.0	Styrene	<1.0
Ethyl methacrylate	<1.0	1,1,2,2-Tetrachloroethane	<1.0
4-Bromofluorobenzene	<10	Toluene	<1.0
Bromoform	<1.0	1,1,1-Trichloroethane	<1.0
Bromomethane	<1.0	1,1,2-Trichloroethane	<1.0
Carbon tetrachloride	<1.0	Trichloroethene	<1.0
Chlorobenzene	<1.0	Trichlorofluoromethane	<1.0
Dibromochloromethane	<1.0	1,2,3-Trichloropropane	<1.0
Chloroethane	<1.0	Vinyl acetate	<20
2-Chloroethyl vinyl ether	<1.0	Vinyl chloride	<1.0
Chloroform	<1.0	Xylenes	<1.0
Chloromethane	<1.0	Tetrachloroethene	<1.0
Dibromomethane	<1.0		
Dichlorodifluoromethane	4.3		

NOTE: Analysis done by EPA method 8240.

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LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48609
DATE: 12/03/92 ag

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill, MW-3
Sampled 11/13/92 @ 1340
Submitted 11/16/92

Constituent	µg/l	Constituent	µg/l
Benzene	<1.0	1,1-Dichloroethane	<1.0
Bromochloromethane	<1.0	1,2-Dichloroethane	<1.0
Bromodichloromethane	<1.0	Iodomethane	<1.0
cis-1,3-Dichloropropene	<1.0	Methylene chloride	<1.0
trans-1,3-Dichloropropene	<1.0	1,1-Dichloroethene	<1.0
1,4-Difluorobenzene	<1.0	trans-1,2-Dichloroethene	<1.0
Ethylbenzene	<1.0	Styrene	<1.0
Ethyl methacrylate	<1.0	1,1,2,2-Tetrachloroethane	<1.0
4-Bromofluorobenzene	<10	Toluene	<1.0
Bromoform	<1.0	1,1,1-Trichloroethane	<1.0
Bromomethane	<1.0	1,1,2-Trichloroethane	<1.0
Carbon tetrachloride	<1.0	Trichloroethene	<1.0
Chlorobenzene	<1.0	Trichlorofluoromethane	<1.0
Dibromochloromethane	<1.0	1,2,3-Trichloropropane	<1.0
Chloroethane	<1.0	Vinyl acetate	<20
2-Chloroethyl vinyl ether	<1.0	Vinyl chloride	<1.0
Chloroform	<1.0	Xylenes	<1.0
Chloromethane	<1.0	Tetrachloroethene	<1.0
Dibromomethane	<1.0		
Dichlorodifluoromethane	<1.0		

NOTE: Analysis done by EPA method 8240.

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LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48608
DATE: 12/03/92 ag

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill, MW-4
Sampled 11/13/92 @ 1220
Submitted 11/16/92

Constituent	µg/l	Constituent	µg/l
Benzene	<1.0	1,1-Dichloroethane	<1.0
Bromochloromethane	<1.0	1,2-Dichloroethane	<1.0
Bromodichloromethane	<1.0	Iodomethane	<1.0
cis-1,3-Dichloropropene	<1.0	Methylene chloride	<1.0
trans-1,3-Dichloropropene	<1.0	1,1-Dichloroethene	<1.0
1,4-Difluorobenzene	<1.0	trans-1,2-Dichloroethene	<1.0
Ethylbenzene	<1.0	Styrene	<1.0
Ethyl methacrylate	<1.0	1,1,2,2-Tetrachloroethane	<1.0
4-Bromofluorobenzene	<10	Toluene	<1.0
Bromoform	<1.0	1,1,1-Trichloroethane	<1.0
Bromomethane	<1.0	1,1,2-Trichloroethane	<1.0
Carbon tetrachloride	<1.0	Trichloroethene	<1.0
Chlorobenzene	<1.0	Trichlorofluoromethane	<1.0
Dibromochloromethane	<1.0	1,2,3-Trichloropropane	<1.0
Chloroethane	<1.0	Vinyl acetate	<20
2-Chloroethyl vinyl ether	<1.0	Vinyl chloride	<1.0
Chloroform	<1.0	Xylenes	<1.0
Chloromethane	<1.0	Tetrachloroethene	<1.0
Dibromomethane	<1.0		
Dichlorodifluoromethane	<1.0		

NOTE: Analysis done by EPA method 8240.

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LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48612
DATE: 12/03/92 ag

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill, MW-5
Sampled 11/14/92 @ 0940
Submitted 11/16/92

Constituent	μg/l	Constituent	μg/l
Benzene	<1.0	1,1-Dichloroethane	<1.0
Bromochloromethane	<1.0	1,2-Dichloroethane	<1.0
Bromodichloromethane	<1.0	Iodomethane	<1.0
cis-1,3-Dichloropropene	<1.0	Methylene chloride	<1.0
trans-1,3-Dichloropropene	<1.0	1,1-Dichloroethene	<1.0
1,4-Difluorobenzene	<1.0	trans-1,2-Dichloroethene	<1.0
Ethylbenzene	<1.0	Styrene	<1.0
Ethyl methacrylate	<1.0	1,1,2,2-Tetrachloroethane	<1.0
4-Bromofluorobenzene	<10	Toluene	<1.0
Bromoform	<1.0	1,1,1-Trichloroethane	<1.0
Bromomethane	<1.0	1,1,2-Trichloroethane	<1.0
Carbon tetrachloride	<1.0	Trichloroethene	<1.0
Chlorobenzene	<1.0	Trichlorofluoromethane	<1.0
Dibromochloromethane	<1.0	1,2,3-Trichloropropane	<1.0
Chloroethane	<1.0	Vinyl acetate	<20
2-Chloroethyl vinyl ether	<1.0	Vinyl chloride	<1.0
Chloroform	<1.0	Xylenes	<1.0
Chloromethane	<1.0	Tetrachloroethene	<1.0
Dibromomethane	<1.0		
Dichlorodifluoromethane	<1.0		

NOTE: Analysis done by EPA method 8240.

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LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48613
DATE: 12/03/92 ag

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill, MW-6
Sampled 11/14/92 @ 1110
Submitted 11/16/92

Constituent	µg/l	Constituent	µg/l
Benzene	<1.0	1,1-Dichloroethane	<1.0
Bromochloromethane	<1.0	1,2-Dichloroethane	<1.0
Bromodichloromethane	<1.0	Iodomethane	<1.0
cis-1,3-Dichloropropene	<1.0	Methylene chloride	4.1
trans-1,3-Dichloropropene	<1.0	1,1-Dichloroethene	<1.0
1,4-Difluorobenzene	<1.0	trans-1,2-Dichloroethene	<1.0
Ethylbenzene	<1.0	Styrene	<1.0
Ethyl methacrylate	<1.0	1,1,2,2-Tetrachloroethane	<1.0
4-Bromofluorobenzene	<10	Toluene	<1.0
Bromoform	<1.0	1,1,1-Trichloroethane	<1.0
Bromomethane	<1.0	1,1,2-Trichloroethane	<1.0
Carbon tetrachloride	<1.0	Trichloroethene	<1.0
Chlorobenzene	<1.0	Trichlorofluoromethane	<1.0
Dibromochloromethane	<1.0	1,2,3-Trichloropropane	<1.0
Chloroethane	<1.0	Vinyl acetate	<20
2-Chloroethyl vinyl ether	<1.0	Vinyl chloride	<1.0
Chloroform	1.7	Xylenes	<1.0
Chloromethane	<1.0	Tetrachloroethene	<1.0
Dibromomethane	<1.0		
Dichlorodifluoromethane	<1.0		

NOTE: Analysis done by EPA method 8240.

ENERGY LABORATORIES, INC.
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LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48608-13
DATE: 12/03/92 ag

WATER VOLATILE SURROGATE RECOVERY

10 μg/l Surrogate Standard Spike

	------% recovery------		
SAMPLE NO.	S1 (TOL)#	S2 (BFB)#	S3 (DCE)#
92-48608	117	105	106
92-48609	97	89	111
92-48610	99	90	114
92-48611	109	99	120
92-48612	99	96	120
92-48613	111	98	102

	QC LIMITS, % Recovery
S1 (TOL) = Toluene-d8	80-120
S2 (BFB) = Bromofluorobenzene	80-120
S3 (DCE) = 1,2-Dichloroethane-d4	80-120

#Column to be used to flag recovery values with an asterisk.

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO:	GeoResearch, Inc.	**LAB NO.:**	92-48608-13
ADDRESS:	P.O. Box 5597 Helena, MT 59604	**DATE:**	12/03/92 ag

WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Spike Added, µg/l	Sample Concentration µg/l	MS Concentration µg/l	MS % Rec. #	QC. Limits Rec., %
1,1-Dichloroethene	5.0	<1.0	3.3	66	60-140
Trichloroethene	5.0	<1.0	4.3	86	60-140
Benzene	5.0	<1.0	5.1	102	60-140
Toluene	5.0	<1.0	5.8	116	60-140
Chlorobenzene	5.0	<1.0	5.5	110	60-140

Compound	Spike Added µg/l	MSD Concentration µg/l	MSD % Rec. #	% RPD #	QC Limits, RPD, %	QC Limits, Rec., %
1,1-Dichloroethene	5.0	3.2	64	2.0	14	60-140
Trichloroethene	5.0	4.1	82	4.8	14	60-140
Benzene	5.0	4.7	94	8.2	11	60-140
Toluene	5.0	5.0	100	15	13	60-140
Chlorobenzene	5.0	4.9	98	12	13	60-140

# Column to be used to flag recovery and RPD values with an asterisk.

GRI GeoResearch, Inc.

CHAIN OF CUSTODY RECORD

TEL. (406) 449-3225
FAX (406) 449-2371

PROJ. NO. 112035	PROJECT NAME LAUREL LAND FILL

SAMPLERS: (Signature)

STAT. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	STATE SOLIDWASTE LIST (ATTACHED) 8260	COD	DISS. METALS	COMMONS / PROPERTIES			REMARKS
MW-4	11-13	11:50		X	MW-4 40mL	3	X						HCl
"	"	12:00		X	" 250mL	1		X					H_2SO_4
"	"	12:20		X	" 250mL	1			X				FILTERED + HNO_3
"	"	12:25		X	" 1 L	1				X			NONE
MW-3	11-13	13:35		X	MW-3 40mL	3	X						HCl
"	"	13:40		X	" 250mL	1		X					H_2SO_4
"	"	14:00		X	" 250mL	1			X				FILTERED + HNO_3
"	"	14:05		X	" 1 L	1				X			NONE
MW-7	11-14	9:20		X	MW-7 40mL	3	X						HCl
"	"	9:35		X	" 250mL	1		X					H_2SO_4
"	"	9:55		X	" 250mL	1			X				FILTERED + HNO_3
"	"	10:10		X	" 1 L	1				X			NONE

Relinquished (Signature)	Date/Time	Received by: (Signature)	Relinguished by: (Signature)	Date/Time	Received by: (Signature)
David Berube	11-16-92 9:55				
Relinquished (Signature)	Date/Time	Received by: (Signature)	Relinguished by: (Signature)	Date/Time	Received by: (Signature)

Relinquished (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks
		Pam Stevenson	11/16/92 0957	

Split Samples:
☐ Accepted ☐ Declined ____________ Signature

GRI GeoResearch, Inc.

910- HELENA • HELENA, MONTANA 59601
TEL. (406) 449-3225
FAX (406) 449-2371

CHAIN OF CUSTODY RECORD

PROJ. NO. 112035

PROJECT NAME LAUREL LANDFILL

SAMPLERS: *(Signature)*

STAT. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	STATE SOLIDWASTE LIST 8260	COD	DIST. METALS	COMMONS / PROPERTIES			REMARKS
MW-2	11-13	15:10		x	MW-2 40 mL	3	X						HCl
"	"	15:15		x	" 250 mL	1		X					H_2SO_4
"	"	15:25		x	" 250 mL	1			X				FILTERED + HNO_3
"	"	15:30		x	" 1 L	1				X			NONE
MW-5	11-14	9:25		x	MW-5 40 mL	3	X						HCl
"		9:40		x	" 250 mL	1		X					H_2SO_4
"		10:00		x	" 250 mL	1			X				FILTERED + HNO_3
"		10:15		x	" 1 L	1				X			NONE
MW-6	11-14	11:00		x	MW-6 40 mL	3	X						HCl
"	"	11:10		x	" 250 mL	1		X					H_2SO_4
"	"	11:15		x	" 250 mL	1			X				FILTERED + HNO_3
"	"	11:20		x	" 1 L	1				X			NONE

Relinquished *(Signature)*	Date/Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date/Time	Received by: *(Signature)*
Darold Berube	11-16-92 9:55				

Relinquished *(Signature)*	Date/Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date/Time	Received by: *(Signature)*

Relinquished *(Signature)*	Date/Time	Received for Laboratory by: *(Signature)*	Date/Time	Remarks
		Pam Stevenson	11/16/92 0957	

Split Samples:
[] Accepted [] Declined
Signature

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.
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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch
115 North Broadway
Billings, MT 59101

LAB NO.: 93-17714
DATE: 06/02/93 da

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill
MW-1
Sampled 05/04/93 @ 1525
Submitted 05/05/93
Analyzed 05/17/93

RECEIVED JUN 3 1993

Constituent	µg/l	Constituent	µg/l
Benzene	<1.0	1,1-Dichloroethane	<1.0
Bromochloromethane	<1.0	1,2-Dichloroethane	<1.0
Bromodichloromethane	<1.0	Iodomethane	<1.0
cis-1,3-Dichloropropene	<1.0	Methylene chloride	10
trans-1,3-Dichloropropene	<1.0	1,1-Dichloroethene	<1.0
1,4-Difluorobenzene	<1.0	trans-1,2-Dichloroethene	<1.0
Ethylbenzene	<1.0	Styrene	<1.0
Ethyl methacrylate	<1.0	1,1,2,2-Tetrachloroethane	<1.0
4-Bromofluorobenzene	<10	Toluene	<1.0
Bromoform	<1.0	1,1,1-Trichloroethane	<1.0
Bromomethane	<1.0	1,1,2-Trichloroethane	<1.0
Carbon tetrachloride	<1.0	Trichloroethene	<1.0
Chlorobenzene	<1.0	Trichlorofluoromethane	<1.0
Dibromochloromethane	<1.0	1,2,3-Trichloropropane	<1.0
Chloroethane	<1.0	Vinyl acetate	<1.0
2-Chloroethyl vinyl ether	<1.0	Vinyl chloride	<1.0
Chloroform	<1.0	Xylenes	<1.0
Chloromethane	<1.0	Tetrachloroethene	<1.0
Dibromomethane	<1.0		
Dichlorodifluoromethane	<1.0		

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch
115 North Broadway
Billings, MT 59101

LAB NO.: 93-17715
DATE: 06/02/93 da

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill
MW-2
Sampled 05/04/93 @ 1710
Submitted 05/05/93
Analyzed 05/12/93

RECEIVED JUN - 3 1993

RECEIVED JUN - 3 1993

Constituent	µg/l	Constituent	µg/l
Benzene	<1.0	1,1-Dichloroethane	<1.0
Bromochloromethane	<1.0	1,2-Dichloroethane	<1.0
Bromodichloromethane	<1.0	Iodomethane	<1.0
cis-1,3-Dichloropropene	<1.0	Methylene chloride	2.2
trans-1,3-Dichloropropene	<1.0	1,1-Dichloroethene	<1.0
1,4-Difluorobenzene	<1.0	trans-1,2-Dichloroethene	<1.0
Ethylbenzene	<1.0	Styrene	<1.0
Ethyl methacrylate	<1.0	1,1,2,2-Tetrachloroethane	<1.0
4-Bromofluorobenzene	<10	Toluene	<1.0
Bromoform	<1.0	1,1,1-Trichloroethane	<1.0
Bromomethane	<1.0	1,1,2-Trichloroethane	<1.0
Carbon tetrachloride	<1.0	Trichloroethene	<1.0
Chlorobenzene	<1.0	Trichlorofluoromethane	1.4
Dibromochloromethane	<1.0	1,2,3-Trichloropropane	<1.0
Chloroethane	<1.0	Vinyl acetate	<1.0
2-Chloroethyl vinyl ether	<1.0	Vinyl chloride	<1.0
Chloroform	<1.0	Xylenes	<1.0
Chloromethane	<1.0	Tetrachloroethene	<1.0
Dibromomethane	<1.0		
Dichlorodifluoromethane	6.1		

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch
115 North Broadway
Billings, MT 59101

LAB NO.: 93-17716
DATE: 06/02/93 da

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill
MW-5
Sampled 05/04/93 @ 1730
Submitted 05/05/93
Analyzed 05/12/93

RECEIVED JUN - 3 1993

Constituent	μg/l	Constituent	μg/l
Benzene	< 1.0	1,1-Dichloroethane	< 1.0
Bromochloromethane	< 1.0	1,2-Dichloroethane	< 1.0
Bromodichloromethane	< 1.0	Iodomethane	< 1.0
cis-1,3-Dichloropropene	< 1.0	Methylene chloride	2.2
trans-1,3-Dichloropropene	< 1.0	1,1-Dichloroethene	< 1.0
1,4-Difluorobenzene	< 1.0	trans-1,2-Dichloroethene	< 1.0
Ethylbenzene	< 1.0	Styrene	< 1.0
Ethyl methacrylate	< 1.0	1,1,2,2-Tetrachloroethane	< 1.0
4-Bromofluorobenzene	< 10	Toluene	< 1.0
Bromoform	< 1.0	1,1,1-Trichloroethane	< 1.0
Bromomethane	< 1.0	1,1,2-Trichloroethane	< 1.0
Carbon tetrachloride	< 1.0	Trichloroethene	< 1.0
Chlorobenzene	< 1.0	Trichlorofluoromethane	1.7
Dibromochloromethane	< 1.0	1,2,3-Trichloropropane	< 1.0
Chloroethane	< 1.0	Vinyl acetate	< 1.0
2-Chloroethyl vinyl ether	< 1.0	Vinyl chloride	< 1.0
Chloroform	< 1.0	Xylenes	< 1.0
Chloromethane	< 1.0	Tetrachloroethene	< 1.0
Dibromomethane	< 1.0		
Dichlorodifluoromethane	6.9		

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch
115 North Broadway
Billings, MT 59101

LAB NO.: 93-17713
DATE: 06/02/93 da

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill
MW-3
Sampled 05/04/93 @ 1330
Submitted 05/05/93
Analyzed 05/14/93

RECEIVED JUN - 3 1993

Constituent	μg/l	Constituent	μg/l
Benzene	<1.0	1,1-Dichloroethane	<1.0
Bromochloromethane	<1.0	1,2-Dichloroethane	<1.0
Bromodichloromethane	<1.0	Iodomethane	<1.0
cis-1,3-Dichloropropene	<1.0	Methylene chloride	10
trans-1,3-Dichloropropene	<1.0	1,1-Dichloroethene	<1.0
1,4-Difluorobenzene	<1.0	trans-1,2-Dichloroethene	<1.0
Ethylbenzene	<1.0	Styrene	<1.0
Ethyl methacrylate	<1.0	1,1,2,2-Tetrachloroethane	<1.0
4-Bromofluorobenzene	<10	Toluene	<1.0
Bromoform	<1.0	1,1,1-Trichloroethane	<1.0
Bromomethane	<1.0	1,1,2-Trichloroethane	<1.0
Carbon tetrachloride	<1.0	Trichloroethene	<1.0
Chlorobenzene	<1.0	Trichlorofluoromethane	<1.0
Dibromochloromethane	<1.0	1,2,3-Trichloropropane	<1.0
Chloroethane	<1.0	Vinyl acetate	<1.0
2-Chloroethyl vinyl ether	<1.0	Vinyl chloride	<1.0
Chloroform	<1.0	Xylenes	<1.0
Chloromethane	<1.0	Tetrachloroethene	<1.0
Dibromomethane	<1.0		
Dichlorodifluoromethane	<1.0		

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch
115 North Broadway
Billings, MT 59101

LAB NO.: 93-17712
DATE: 06/02/93 da

WATER ANALYSIS

RECEIVED JUN - 3 1993

Proj. No. 112035, Laurel Landfill
MW-4
Sampled 05/04/93 @ 1110
Submitted 05/05/93
Analyzed 05/13/93

Constituent	μg/l
Benzene	< 1.0
Bromochloromethane	< 1.0
Bromodichloromethane	< 1.0
cis-1,3-Dichloropropene	< 1.0
trans-1,3-Dichloropropene	< 1.0
1,4-Difluorobenzene	< 1.0
Ethylbenzene	< 1.0
Ethyl methacrylate	< 1.0
4-Bromofluorobenzene	< 10
Bromoform	< 1.0
Bromomethane	< 1.0
Carbon tetrachloride	< 1.0
Chlorobenzene	< 1.0
Dibromochloromethane	< 1.0
Chloroethane	< 1.0
2-Chloroethyl vinyl ether	< 1.0
Chloroform	< 1.0
Chloromethane	< 1.0
Dibromomethane	< 1.0
Dichlorodifluoromethane	< 1.0

Constituent	μg/l
1,1-Dichloroethane	< 1.0
1,2-Dichloroethane	< 1.0
Iodomethane	< 1.0
Methylene chloride	10
1,1-Dichloroethene	< 1.0
trans-1,2-Dichloroethene	< 1.0
Styrene	< 1.0
1,1,2,2-Tetrachloroethane	< 1.0
Toluene	< 1.0
1,1,1-Trichloroethane	< 1.0
1,1,2-Trichloroethane	< 1.0
Trichloroethene	< 1.0
Trichlorofluoromethane	< 1.0
1,2,3-Trichloropropane	< 1.0
Vinyl acetate	< 1.0
Vinyl chloride	< 1.0
Xylenes	< 1.0
Tetrachloroethene	< 1.0

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch
115 North Broadway
Billings, MT 59101

LAB NO.: 93-17711
DATE: 06/02/93 da

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill
MW-6
Sampled 05/04/93 @ 0955
Submitted 05/05/93
Analyzed 05/13/93

RECEIVED JUN - 3 1993

Constituent	µg/l
Benzene	<1.0
Bromochloromethane	<1.0
Bromodichloromethane	<1.0
cis-1,3-Dichloropropene	<1.0
trans-1,3-Dichloropropene	<1.0
1,4-Difluorobenzene	<1.0
Ethylbenzene	<1.0
Ethyl methacrylate	<1.0
4-Bromofluorobenzene	<10
Bromoform	<1.0
Bromomethane	<1.0
Carbon tetrachloride	<1.0
Chlorobenzene	<1.0
Dibromochloromethane	<1.0
Chloroethane	<1.0
2-Chloroethyl vinyl ether	<1.0
Chloroform	3.0
Chloromethane	<1.0
Dibromomethane	<1.0
Dichlorodifluoromethane	<1.0

Constituent	µg/l
1,1-Dichloroethane	<1.0
1,2-Dichloroethane	<1.0
Iodomethane	<1.0
Methylene chloride	10
1,1-Dichloroethene	<1.0
trans-1,2-Dichloroethene	<1.0
Styrene	<1.0
1,1,2,2-Tetrachloroethane	<1.0
Toluene	<1.0
1,1,1-Trichloroethane	<1.0
1,1,2-Trichloroethane	<1.0
Trichloroethene	<1.0
Trichlorofluoromethane	<1.0
1,2,3-Trichloropropane	<1.0
Vinyl acetate	<1.0
Vinyl chloride	<1.0
Xylenes	<1.0
Tetrachloroethene	<1.0

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch
115 North Broadway
Billings, MT 59101

LAB NO.: 93-17717
DATE: 06/02/93 da

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill
MW-7
Sampled 05/04/93 @ 1655
Submitted 05/05/93
Analyzed 05/12/93

RECEIVED JUN - 3 1993

Constituent	µg/l
Benzene	< 1.0
Bromochloromethane	< 1.0
Bromodichloromethane	< 1.0
cis-1,3-Dichloropropene	< 1.0
trans-1,3-Dichloropropene	< 1.0
1,4-Difluorobenzene	< 1.0
Ethylbenzene	< 1.0
Ethyl methacrylate	< 1.0
4-Bromofluorobenzene	< 10
Bromoform	< 1.0
Bromomethane	< 1.0
Carbon tetrachloride	< 1.0
Chlorobenzene	< 1.0
Dibromochloromethane	< 1.0
Chloroethane	< 1.0
2-Chloroethyl vinyl ether	< 1.0
Chloroform	2.3
Chloromethane	< 1.0
Dibromomethane	< 1.0
Dichlorodifluoromethane	< 1.0

Constituent	µg/l
1,1-Dichloroethane	< 1.0
1,2-Dichloroethane	< 1.0
Iodomethane	< 1.0
Methylene chloride	7.5
1,1-Dichloroethene	< 1.0
trans-1,2-Dichloroethene	< 1.0
Styrene	< 1.0
1,1,2,2-Tetrachloroethane	< 1.0
Toluene	< 1.0
1,1,1-Trichloroethane	< 1.0
1,1,2-Trichloroethane	< 1.0
Trichloroethene	< 1.0
Trichlorofluoromethane	< 1.0
1,2,3-Trichloropropane	< 1.0
Vinyl acetate	< 1.0
Vinyl chloride	< 1.0
Xylenes	< 1.0
Tetrachloroethene	< 1.0

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch
115 North Broadway
Billings, MT 59101

LAB NO.: 93-17714
DATE: 06/02/93 da

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill
MW-1
Sampled 05/04/93 @ 1525
Submitted 05/05/93

RECEIVED JUN - 3 1993

Constituent	mg/l (ppm)		Date Analyzed
Potassium	37		05/06/93
Sodium	4400		05/06/93
Calcium	395		05/06/93
Magnesium	3990		05/06/93
Sulfate	25000		05/12/93
Chloride	189		05/12/93
Carbonate	0		05/06/93
Bicarbonate	1020		05/06/93
Total Dissolved Solids @ 180° C	38000		05/07/93
Total Alkalinity as $CaCO_3$	834		05/06/93
Specific Conductance @ 25°C	26200	μmhos/cm	05/06/93
pH	7.0	s.u.	05/06/93
Nitrate as N	<0.05		05/06/93
Ammonia as N	0.3		05/06/93
Chemical Oxygen Demand	38		05/06/93
Total Suspended Solids	1470		05/06/93
Total Cyanide	<0.005		05/07/93
Dissolved Metals			
Arsenic	<0.005		05/10/93
Barium	<0.6 *		05/07/93
Cadmium	<0.006*		05/07/93
Chromium	<0.06*		05/07/93
Iron	<0.03		05/07/93
Lead	<0.06*		05/07/93
Manganese	10.1		05/07/93
Mercury	<0.001		05/13/93
Selenium	<0.005		05/07/93
Silver	<0.03*		05/07/93

*Detection limit raised due to sample matrix interference.

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch
115 North Broadway
Billings, MT 59101

LAB NO.: 93-17715
DATE: 06/02/93 da

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill
MW-2
Sampled 05/04/93 @ 1710
Submitted 05/05/93

RECEIVED JUN - 3 1993

Constituent	mg/l (ppm)		Date Analyzed
Potassium	34		05/06/93
Sodium	2350		05/06/93
Calcium	392		05/06/93
Magnesium	3030		05/06/93
Sulfate	16700		05/12/93
Chloride	178		05/12/93
Carbonate	0		05/06/93
Bicarbonate	581		05/06/93
Total Dissolved Solids @ 180° C	24900		05/07/93
Total Alkalinity as $CaCO_3$	476		05/06/93
Specific Conductance @ 25°C	18700	μmhos/cm	05/06/93
pH	7.4	s.u.	05/06/93
Nitrate as N	52.4		05/06/93
Ammonia as N	<0.1		05/06/93
Chemical Oxygen Demand	57		05/06/93
Total Suspended Solids	4500		05/06/93
Total Cyanide	<0.005		05/07/93
Dissolved Metals			
Arsenic	<0.005		05/10/93
Barium	<0.6*		05/07/93
Cadmium	<0.006*		05/07/93
Chromium	<0.06*		05/07/93
Iron	<0.03		05/07/93
Lead	<0.06*		05/07/93
Manganese	<0.06*		05/07/93
Mercury	<0.001		05/13/93
Selenium	0.25		05/07/93
Silver	<0.03*		05/07/93

*Detection limit increased due to sample matrix interference.

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch
115 North Broadway
Billings, MT 59101

LAB NO.: 93-17716
DATE: 06/02/93 da

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill
MW-5
Sampled 05/04/93 @ 1730
Submitted 05/05/93

RECEIVED JUN - 3 1993

Constituent	mg/l (ppm)		Date Analyzed
Potassium	33		04/27/93
Sodium	2350		04/27/93
Calcium	391		04/27/93
Magnesium	3030		04/27/93
Sulfate	16700		05/12/93
Chloride	190		05/12/93
Carbonate	0		05/06/93
Bicarbonate	582		05/06/93
Total Dissolved Solids @ 180° C	25000		04/26/93
Total Alkalinity as $CaCO_3$	477		05/06/93
Specific Conductance @ 25°C	18700	μmhos/cm	04/26/93
pH	7.4	s.u.	05/06/93
Nitrate as N	51.0		05/06/93
Ammonia as N	<0.1		05/06/93
Chemical Oxygen Demand	57		05/06/93
Total Suspended Solids	4040		05/06/93
Total Cyanide	<0.005		05/07/93
Dissolved Metals			
Arsenic	<0.005		05/10/93
Barium	<0.6*		05/07/93
Cadmium	<0.006*		05/07/93
Chromium	<0.06*		05/07/93
Iron	<0.03		05/07/93
Lead	<0.06*		05/07/93
Manganese	<0.06*		05/07/93
Mercury	<0.001		05/13/93
Selenium	0.26		05/07/93
Silver	<0.03*		05/07/93

*Detection limit increased due to sample matrix interference.

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch
115 North Broadway
Billings, MT 59101

LAB NO.: 93-17713
DATE: 06/02/93 da

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill
MW-3
Sampled 05/04/93 @ 1330
Submitted 05/05/93

RECEIVED JUN - 3 1993

Constituent	mg/l (ppm)		Date Analyzed
Potassium	20		05/11/93
Sodium	10200		05/11/93
Calcium	355		05/11/93
Magnesium	702		05/11/93
Sulfate	23400		05/12/93
Chloride	304		05/12/93
Carbonate	0		05/06/93
Bicarbonate	1360		05/06/93
Total Dissolved Solids @ 180° C	35700		05/07/93
Total Alkalinity as $CaCO_3$	1120		05/06/93
Specific Conductance @ 25°C	32700	μmhos/cm	05/06/93
pH	7.7	s.u.	05/06/93
Nitrate as N	<0.05		05/06/93
Ammonia as N	4.1		05/06/93
Chemical Oxygen Demand	<1		05/06/93
Total Suspended Solids	2760		05/06/93
Total Cyanide	<0.005		05/07/93
Dissolved Metals			
Arsenic	<0.005		05/10/93
Barium	<0.1		05/06/93
Cadmium	<0.001		05/06/93
Chromium	<0.01		05/06/93
Iron	1.02		05/06/93
Lead	0.01		05/06/93
Manganese	0.13		05/06/93
Mercury	<0.001		05/13/93
Selenium	<0.005		05/07/93
Silver	<0.005		05/06/93

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch
115 North Broadway
Billings, MT 59101

LAB NO.: 93-17712
DATE: 06/02/93 da

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill
MW-4
Sampled 05/04/93 @ 1110
Submitted 05/05/93

RECEIVED JUN - 3 1993

Constituent	mg/l (ppm)	Date Analyzed
Potassium	21	05/06/93
Sodium	987	05/06/93
Calcium	416	05/06/93
Magnesium	798	05/06/93
Sulfate	5560	05/12/93
Chloride	73	05/12/93
Carbonate	0	05/06/93
Bicarbonate	723	05/06/93
Total Dissolved Solids @ 180° C	8900	05/07/93
Total Alkalinity as $CaCO_3$	592	05/06/93
Specific Conductance @ 25°C	8030 µmhos/cm	05/06/93
pH	7.4 s.u.	05/06/93
Nitrate as N	1.73	05/06/93
Ammonia as N	0.3	05/06/93
Chemical Oxygen Demand	10	05/06/93
Total Suspended Solids	5500	05/06/93
Total Cyanide	<0.005	05/07/93
Dissolved Metals		
Arsenic	<0.005	05/10/93
Barium	<0.1	05/13/93
Cadmium	<0.001	05/13/93
Chromium	0.01	05/13/93
Iron	<0.03	05/13/93
Lead	<0.01	05/17/93
Manganese	0.84	05/15/93
Mercury	<0.001	05/13/93
Selenium	0.10	05/07/93
Silver	<0.005	05/13/93

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch
115 North Broadway
Billings, MT 59101

LAB NO.: 93-17717
DATE: 06/02/93 da

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill
MW-7
Sampled 05/04/93 @ 1655
Submitted 05/05/93

RECEIVED JUN - 3 1993

Constituent	mg/l (ppm)	Date Analyzed
Potassium	<1	05/06/93
Sodium	<1	05/06/93
Calcium	<1	05/06/93
Magnesium	<1	05/06/93
Sulfate	2	05/12/93
Chloride	<1	05/12/93
Carbonate	0	05/06/93
Bicarbonate	0	05/06/93
Total Dissolved Solids @ 180° C	<1	05/07/93
Total Alkalinity as $CaCO_3$	0	05/06/93
Specific Conductance @ 25°C	38 µmhos/cm	05/06/93
pH	4.0 s.u.	05/06/93
Nitrate as N	<0.05	05/06/93
Ammonia as N	<0.1	05/06/93
Chemical Oxygen Demand	<1	05/06/93
Total Suspended Solids	1	05/06/93
Total Cyanide	<0.005	05/07/93
Dissolved Metals		
Arsenic	<0.005	05/10/93
Barium	<0.1	05/06/93
Cadmium	<0.001	05/06/93
Chromium	<0.01	05/06/93
Iron	0.25	05/06/93
Lead	<0.01	05/06/93
Manganese	<0.01	05/06/93
Mercury	<0.001	05/13/93
Selenium	<0.005	05/07/93
Silver	<0.005	05/06/93

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch
115 North Broadway
Billings, MT 59101

LAB NO.: 93-17711 -17
DATE: 06/02/93 da

RECEIVED JUN - 3 1993

WATER VOLATILE SURROGATE RECOVERY

10 μg/l Surrogate Standard Spike

	------% recovery------		
	S1	S2	S3
SAMPLE NO.	(TOL)#	(BFB)#	(DCE)#
93-17711	100	92	105
93-17712	99	94	106
93-17713	105	82	115
93-17714	102	94	102
93-17715	95	95	107
93-17716	94	93	110
93-17717	99	101	99

	QC LIMITS, % Recovery
S1 (TOL) = Toluene-d8	80-120
S2 (BFB) = Bromofluorobenzene	80-120
S3 (DCE) = 1,2-Dichloroethane-d4	80-120

#Column to be used to flag recovery values with an asterisk.

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch
115 North Broadway
Billings, MT 59101

LAB NO.: 93-17711
DATE: 06/02/93 da

RECEIVED JUN - 3 1993

MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Spike Added, µg/l	Sample Concentration µg/l	MS Concentration µg/l	MS % Rec. #	QC. Limits Rec., %
1,1-Dichloroethene	5.0	<1.0	4.9	98	60-140
Trichloroethene	5.0	<1.0	5.5	110	60-140
Benzene	5.0	<1.0	5.1	102	60-140
Toluene	5.0	<1.0	6.7	134	60-140
Chlorobenzene	5.0	<1.0	6.3	126	60-140

Compound	Spike Added µg/l	MSD Concentration µg/l	MSD % Rec. #	% RPD #	QC Limits, RPD, %	QC Limits, Rec., %
1,1-Dichloroethene	5.0	4.5	90	8.5	14	60-140
Trichloroethene	5.0	5.9	118	7.0	14	60-140
Benzene	5.0	5.5	110	7.5	11	60-140
Toluene	5.0	6.2	124	7.8	13	60-140
Chlorobenzene	5.0	6.1	122	3.2	13	60-140

# Column to be used to flag recovery and RPD values with an asterisk.

GRI GeoResearch, Inc.

CHAIN OF CUSTODY RECORD

910- H

GEO RESEARCH

GEORESEARCH, INC.
115 North Broadway
Billings, MT 59101
TEL (406) 248-6771
FAX (406) 248-6770

PROJ. NO. 112035

PROJECT NAME Laurel Landfill

SAMPLERS: (Signature) Margaret M. Hofacher

Energy Labs

pg 1 of 2

STAT. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CON- TAINERS	40 ml glass w/HCl	500 ml plastic w/H2SO4	1 l plastic - no preservation	250 ml plastic w/HNO3 (filtered)			REMARKS
													Montana Solid Waste List (see attached)
	5/4/93	0955		X	MW-6	2	2						VOC, 8260
	5/4/93	1110		X	MW-4	2	2						VOC, 8260
	5/4/93	1115		X	MW-4	1			1				major minerals, general parameters
	5/4/93	1105		X	MW-4	1		1					N, COD
	5/4/93	1235		X	MW-4	1				1			dissolved metals
	5/4/93	1330		X	MW-3	2	2						VOC, 8260
	5/4/93	1335		X	MW-3	1		1					N, COD
	5/4/93	1400		X	MW-3	1			1				maj minerals, general param
	5/4/93	1445		X	MW-3	1				1			dissolved metals
	5/4/93	1525		X	MW-1	2	2						VOC, 8260
	5/4/93	1530		X	MW-1	1		1					N, COD
	5/4/93	1540		X	MW-1	1			1				maj minerals, common parameters
	5/4/93	1630		X	MW-1	1				1			dissolved metals

linquished (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Margaret M. Hofacher	5/5/93 0900				

linquished (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)

inquished (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks
		Janet Weber	5/5/93 0900	

Split Samples:
[] Accepted [] Declined

GRI GeoResearch, Inc.

CHAIN OF CUSTODY RECORD

910- 601

GEORESEARCH, INC.
115 North Broadway
Billings, MT 59101
TEL (406) 248-6771
FAX (406) 248-6770

Energy Labs

pg 2 of 2

PROJ. NO.	PROJECT NAME
112035	Laurel Landfill

SAMPLERS: (Signature) Margaret M. Hofacker

STAT. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	40 ml glass w/ HCl	500 ml plastic w/ H2SO4	1 l plastic - no preserv	250 ml plastic w/ HNO3 (filtered)			REMARKS Montana Solid Waste List (see attached)
	5/4/93	1710		X	MW-2	2	2						VOC, 8260
	5/4/93	1715		X	MW-2	1		1					N, COD
	5/4/93	1750		X	MW-2	1			1				maj minerals, general param
	5/4/93	1900		X	MW-2	1				1			dissolved metals
	5/4/93	1730		X	MW-5	2	2						VOC, 8260
	5/4/93	1735		X	MW-5	1		1	~~1~~				N, COD
	5/4/93	1915		X	MW-5	1			1				maj minerals, general param
	5/4/93	1930		X	MW-5	1				1			dissolved metals
	5/4/93	1655			MW-7	2	2						VOC, 8260
	5/4/93	1700			MW-7	1		1	~~1~~				N, COD
	5/4/93	1755			MW-7	1			1				maj minerals, general param
	5/4/93	1830			MW-7	1				1			dissolved metals

Relinquished (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Margaret M. Hofacker	5/5/93 0900				
Relinquished (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)

Relinquished (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks
		Janet Weber	5/5/93 0900	

Split Samples:
[] Accepted [] Declined
Signature

ENERGY LABORATORIES

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: 93-42565
DATE: 10/11/93 jmw
REVISED: 01/26/94 crp

WATER ANALYSIS

Laurel Landfill, Laurel, MT
993LAU001 MW-4
Sampled 09/10/93 @ 0711
Submitted 09/13/93
Analyzed 09/21/93

RECEIVED JAN 27 1994

PURGEABLE ORGANICS
EPA METHOD 8260 - LONG LIST

Constituent	µg/l
Acetone	<40
Acrylonitrile	<40
Benzene	<2.0
Bromochloromethane	<2.0
Bromodichloromethane	<2.0
Bromoform	<2.0
Bromomethane	<2.0
2-Butanone (Methyl Ethyl Ketone)	<40
Carbon disulfide	<2.0
Carbon tetrachloride	<2.0
Chlorobenzene	<2.0
Chlorodibromomethane	<2.0
Chloroethane	<2.0
Chloroform	<2.0
Chloromethane	<2.0
1,2-Dibromo-3-chloropropane (DBCP)	<2.0
1,2-Dibromoethane (EDB)	<2.0
Dibromomethane	<2.0
1,2-Dichlorobenzene	<2.0
1,4-Dichlorobenzene	<2.0
1,1-Dichloroethane	<2.0
1,2-Dichloroethane	<2.0
1,1-Dichloroethene	<2.0
cis-1,2-Dichloroethene	<2.0
trans-1,2-Dichloroethene	<2.0
1,2-Dichloropropane	<2.0

Constituent	µg/l
cis-1,3-Dichloropropene	<2.0
trans-1,3-Dichloropropene	<2.0
Ethylbenzene	<2.0
2-Hexanone	<40
Iodomethane	<2.0
4-Methyl-2-pentanone (MIBK)	<40
Methylene chloride (Dichloromethane)	<2.0
Styrene	<2.0
Tetrachloroethene (Tetrachloroethylene)	<2.0
1,1,1,2-Tetrachloroethane	<2.0
1,1,2,2-Tetrachloroethane	<2.0
1,1,1-Trichloroethane	<2.0
1,1,2-Trichloroethane	<2.0
Trichloroethene (Trichloroethylene)	<2.0
Trichlorofluoromethane	<2.0
1,2,3-Trichloropropane	<2.0
Toluene	<2.0
Vinyl acetate	<2.0
Vinyl chloride (chloroethene)	<2.0
Xylenes:	<2.0
M	
P	
O	
trans-1,4-Dichloro-2-Butene	<2.0
Dichlorodifluoromethane	<2.0

Practical quantitation limit reflects a 2x dilution. The sample was diluted due to non-target compound matrix interference.

NOTE: Method 8260 is the capillary equivalent to Method 8240.

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: 93-42566
DATE: 10/11/93 jmw
REVISED: 01/26/94 crp

WATER ANALYSIS

Laurel Landfill, Laurel, MT
993LAU002 MW-3
Sampled 09/10/93 @ 1010
Submitted 09/13/93
Analyzed 09/21/93

RECEIVED JAN 27 1994

PURGEABLE ORGANICS
EPA METHOD 8260 - LONG LIST

Constituent	µg/l
Acetone	<40
Acrylonitrile	<40
Benzene	<2.0
Bromochloromethane	<2.0
Bromodichloromethane	<2.0
Bromoform	<2.0
Bromomethane	<2.0
2-Butanone (Methyl Ethyl Ketone)	<40
Carbon disulfide	<2.0
Carbon tetrachloride	<2.0
Chlorobenzene	<2.0
Chlorodibromomethane	<2.0
Chloroethane	<2.0
Chloroform	<2.0
Chloromethane	<2.0
1,2-Dibromo-3-chloropropane (DBCP)	<2.0
1,2-Dibromoethane (EDB)	<2.0
Dibromomethane	<2.0
1,2-Dichlorobenzene	<2.0
1,4-Dichlorobenzene	<2.0
1,1-Dichloroethane	<2.0
1,2-Dichloroethane	<2.0
1,1-Dichloroethene	<2.0
cis-1,2-Dichloroethene	<2.0
trans-1,2-Dichloroethene	<2.0
1,2-Dichloropropane	<2.0

Constituent	µg/l
cis-1,3-Dichloropropene	<2.0
trans-1,3-Dichloropropene	<2.0
Ethylbenzene	<2.0
2-Hexanone	<40
Iodomethane	<2.0
4-Methyl-2-pentanone (MIBK)	<40
Methylene chloride (Dichloromethane)	<2.0
Styrene	<2.0
Tetrachloroethene (Tetrachloroethylene)	<2.0
1,1,1,2-Tetrachloroethane	<2.0
1,1,2,2-Tetrachloroethane	<2.0
1,1,1-Trichloroethane	<2.0
1,1,2-Trichloroethane	<2.0
Trichloroethene (Trichloroethylene)	<2.0
Trichlorofluoromethane	<2.0
1,2,3-Trichloropropane	<2.0
Toluene	<2.0
Vinyl acetate	<2.0
Vinyl chloride (chloroethene)	<2.0
Xylenes:	<2.0
M	
P	
O	
trans-1,4-Dichloro-2-Butene	<2.0
Dichlorodifluoromethane	<2.0

Practical quantitation limit reflects a 2x dilution. The sample was diluted due to non-target compound sample matrix interference.

NOTE: Method 8260 is the capillary equivalent to Method 8240.

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: 93-42567
DATE: 10/11/93 jmw
REVISED: 01/26/94 crp

WATER ANALYSIS

Laurel Landfill, Laurel, MT
993LAU003 MW -1
Sampled 09/10/93 @ 1303
Submitted 09/13/93
Analyzed 09/22/93

RECEIVED JAN 27 1994

Constituent	µg/l
PURGEABLE ORGANICS EPA METHOD 8260 - LONG LIST	
Acetone	<40
Acrylonitrile	<40
Benzene	<2.0
Bromochloromethane	<2.0
Bromodichloromethane	<2.0
Bromoform	<2.0
Bromomethane	<2.0
2-Butanone (Methyl Ethyl Ketone)	<40
Carbon disulfide	<2.0
Carbon tetrachloride	<2.0
Chlorobenzene	<2.0
Chlorodibromomethane	<2.0
Chloroethane	<2.0
Chloroform	<2.0
Chloromethane	<2.0
1,2-Dibromo-3-chloropropane (DBCP)	<2.0
1,2-Dibromoethane (EDB)	<2.0
Dibromomethane	<2.0
1,2-Dichlorobenzene	<2.0
1,4-Dichlorobenzene	<2.0
1,1-Dichloroethane	<2.0
1,2-Dichloroethane	<2.0
1,1-Dichloroethene	<2.0
cis-1,2-Dichloroethene	<2.0
trans-1,2-Dichloroethene	<2.0
1,2-Dichloropropane	<2.0
cis-1,3-Dichloropropene	<2.0
trans-1,3-Dichloropropene	<2.0
Ethylbenzene	<2.0
2-Hexanone	<40
Iodomethane	<2.0
4-Methyl-2-pentanone (MIBK)	<40
Methylene chloride (Dichloromethane)	<2.0
Styrene	<2.0
Tetrachloroethene (Tetrachloroethylene)	<2.0
1,1,1,2-Tetrachloroethane	<2.0
1,1,2,2-Tetrachloroethane	<2.0
1,1,1-Trichloroethane	<2.0
1,1,2-Trichloroethane	<2.0
Trichloroethene (Trichloroethylene)	<2.0
Trichlorofluoromethane	<2.0
1,2,3-Trichloropropane	<2.0
Toluene	<2.0
Vinyl acetate	<2.0
Vinyl chloride (chloroethene)	<2.0
Xylenes:	<2.0
M	
P	
O	
trans-1,4-Dichloro-2-Butene	<2.0
Dichlorodifluoromethane	<2.0

Practical quantitation limit reflects a 2x diltuion. The sample was diluted due to non-target compound sample matrix interference.

NOTE: Method 8260 is the capillary equivalent to Method 8240.

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: 93-42568
DATE: 10/11/93 jmw
REVISED: 01/26/94 crp

WATER ANALYSIS

Laurel Landfill, Laurel, MT
993LAU004
Sampled 09/10/93 @ 1440
Submitted 09/13/93
Analyzed 09/20/93

Equip
Rinsate

RECEIVED JAN 27 1994

Constituent	µg/l	Constituent	µg/l
PURGEABLE ORGANICS EPA METHOD 8260 - LONG LIST			
Acetone	<20	cis-1,3-Dichloropropene	<1.0
Acrylonitrile	<20	trans-1,3-Dichloropropene	<1.0
Benzene	<1.0	Ethylbenzene	<1.0
Bromochloromethane	<1.0	2-Hexanone	<20
Bromodichloromethane	<1.0	Iodomethane	<1.0
Bromoform	<1.0	4-Methyl-2-pentanone (MIBK)	<20
Bromomethane	<1.0	Methylene chloride (Dichloromethane)	<1.0
2-Butanone (Methyl Ethyl Ketone)	<20	Styrene	<1.0
Carbon disulfide	<1.0	Tetrachloroethene (Tetrachloroethylene)	<1.0
Carbon tetrachloride	<1.0	1,1,1,2-Tetrachloroethane	<1.0
Chlorobenzene	<1.0	1,1,2,2-Tetrachloroethane	<1.0
Chlorodibromomethane	<1.0	1,1,1-Trichloroethane	<1.0
Chloroethane	<1.0	1,1,2-Trichloroethane	<1.0
Chloroform	<1.0	Trichloroethene (Trichloroethylene)	<1.0
Chloromethane	<1.0	Trichlorofluoromethane	<1.0
1,2-Dibromo-3-chloropropane (DBCP)	<1.0	1,2,3-Trichloropropane	<1.0
1,2-Dibromoethane (EDB)	<1.0	Toluene	<1.0
Dibromomethane	<1.0	Vinyl acetate	<1.0
1,2-Dichlorobenzene	<1.0	Vinyl chloride (chloroethene)	<1.0
1,4-Dichlorobenzene	<1.0	Xylenes:	<1.0*
1,1-Dichloroethane	<1.0	M	
1,2-Dichloroethane	<1.0	P	
1,1-Dichloroethene	<1.0	O	
cis-1,2-Dichloroethene	<1.0	trans-1,4-Dichloro-2-Butene	<1.0
trans-1,2-Dichloroethene	<1.0	Dichlorodifluoromethane	<1.0
1,2-Dichloropropane	<1.0		

*Present but less than the practical quantitation limit.

NOTE: Method 8260 is the capillary equivalent to Method 8240.

ENERGY LABORATORIES

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FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO:	Margaret Hofacker	**LAB NO.:**	93-42569
ADDRESS:	GeoResearch, Inc. 115 N. Broadway Billings, MT 59101	**DATE:**	10/11/93 jmw
		REVISED:	01/26/94 crp

WATER ANALYSIS

Laurel Landfill, Laurel, MT
993LAU005 MW-2
Sampled 09/10/93 @ 1510
Submitted 09/13/93
Analyzed 09/22/93

RECEIVED JAN 27 1994

PURGEABLE ORGANICS
EPA METHOD 8260 - LONG LIST

Constituent	µg/l
Acetone	<20
Acrylonitrile	<20
Benzene	<1.0
Bromochloromethane	<1.0
Bromodichloromethane	<1.0
Bromoform	<1.0
Bromomethane	<1.0
2-Butanone (Methyl Ethyl Ketone)	<20
Carbon disulfide	<1.0
Carbon tetrachloride	<1.0
Chlorobenzene	<1.0
Chlorodibromomethane	<1.0
Chloroethane	<1.0
Chloroform	<1.0
Chloromethane	<1.0
1,2-Dibromo-3-chloropropane (DBCP)	<1.0
1,2-Dibromoethane (EDB)	<1.0
Dibromomethane	<1.0
1,2-Dichlorobenzene	<1.0
1,4-Dichlorobenzene	<1.0
1,1-Dichloroethane	<1.0
1,2-Dichloroethane	<1.0
1,1-Dichloroethene	<1.0
cis-1,2-Dichloroethene	<1.0
trans-1,2-Dichloroethene	<1.0
1,2-Dichloropropane	<1.0

Constituent	µg/l
cis-1,3-Dichloropropene	<1.0
trans-1,3-Dichloropropene	<1.0
Ethylbenzene	<1.0
2-Hexanone	<20
Iodomethane	<1.0
4-Methyl-2-pentanone (MIBK)	<20
Methylene chloride (Dichloromethane)	1.1
Styrene	<1.0
Tetrachloroethene (Tetrachloroethylene)	<1.0
1,1,1,2-Tetrachloroethane	<1.0
1,1,2,2-Tetrachloroethane	<1.0
1,1,1-Trichloroethane	<1.0*
1,1,2-Trichloroethane	<1.0
Trichloroethene (Trichloroethylene)	<1.0
Trichlorofluoromethane	1.4
1,2,3-Trichloropropane	<1.0
Toluene	<1.0
Vinyl acetate	<1.0
Vinyl chloride (chloroethene)	<1.0
Xylenes:	<1.0
M	
P	
O	
trans-1,4-Dichloro-2-Butene	<1.0
Dichlorodifluoromethane	4.4

*Present but less than the practical quantitation limit.

NOTE: Method 8260 is the capillary equivalent to Method 8240.

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: 93-42570
DATE: 10/11/93 jmw
REVISED: 01/26/94 crp

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WATER ANALYSIS

Laurel Landfill, Laurel, MT
993LAU006
Sampled 09/10/93 @ 1615
Submitted 09/13/93
Analyzed 09/22/93

DUP MW-2

PURGEABLE ORGANICS
EPA METHOD 8260 - LONG LIST

Constituent	µg/l
Acetone	<20
Acrylonitrile	<20
Benzene	<1.0
Bromochloromethane	<1.0
Bromodichloromethane	<1.0
Bromoform	<1.0
Bromomethane	<1.0
2-Butanone (Methyl Ethyl Ketone)	<20
Carbon disulfide	<1.0
Carbon tetrachloride	<1.0
Chlorobenzene	<1.0
Chlorodibromomethane	<1.0
Chloroethane	<1.0
Chloroform	<1.0
Chloromethane	<1.0
1,2-Dibromo-3-chloropropane (DBCP)	<1.0
1,2-Dibromoethane (EDB)	<1.0
Dibromomethane	<1.0
1,2-Dichlorobenzene	<1.0
1,4-Dichlorobenzene	<1.0
1,1-Dichloroethane	<1.0
1,2-Dichloroethane	<1.0
1,1-Dichloroethene	<1.0
cis-1,2-Dichloroethene	<1.0
trans-1,2-Dichloroethene	<1.0
1,2-Dichloropropane	<1.0

Constituent	µg/l
cis-1,3-Dichloropropene	<1.0
trans-1,3-Dichloropropene	<1.0
Ethylbenzene	<1.0
2-Hexanone	<20
Iodomethane	<1.0
4-Methyl-2-pentanone (MIBK)	<20
Methylene chloride (Dichloromethane)	2.7
Styrene	<1.0
Tetrachloroethene (Tetrachloroethylene)	<1.0
1,1,1,2-Tetrachloroethane	<1.0
1,1,2,2-Tetrachloroethane	<1.0
1,1,1-Trichloroethane	<1.0
1,1,2-Trichloroethane	<1.0
Trichloroethene (Trichloroethylene)	<1.0
Trichlorofluoromethane	2.2
1,2,3-Trichloropropane	<1.0
Toluene	<1.0
Vinyl acetate	<1.0
Vinyl chloride (chloroethene)	<1.0
Xylenes:	<1.0
M	
P	
O	
trans-1,4-Dichloro-2-Butene	<1.0
Dichlorodifluoromethane	5.4

NOTE: Method 8260 is the capillary equivalent to Method 8240.

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: 93-43727
DATE: 10/15/93 jmw
REVISED: 01/26/94 crp

RECEIVED JAN 27 1994

WATER ANALYSIS

Laurel Landfill, Laurel, MT
93LAU007 93mw-20
Sampled 09/21/93 @ 1814
Submitted 09/22/93
Analyzed 10/05/93

PURGEABLE ORGANICS
EPA METHOD 8260 - LONG LIST

Constituent	µg/l
Acetone	<20
Acrylonitrile	<20
Benzene	<1.0
Bromochloromethane	<1.0
Bromodichloromethane	<1.0
Bromoform	<1.0
Bromomethane	<1.0
2-Butanone (Methyl Ethyl Ketone)	<20
Carbon disulfide	<1.0
Carbon tetrachloride	<1.0
Chlorobenzene	<1.0
Chlorodibromomethane	<1.0
Chloroethane	<1.0
Chloroform	<1.0
Chloromethane	<1.0
1,2-Dibromo-3-chloropropane (DBCP)	<1.0
1,2-Dibromoethane (EDB)	<1.0
Dibromomethane	<1.0
1,2-Dichlorobenzene	<1.0
1,4-Dichlorobenzene	<1.0
1,1-Dichloroethane	<1.0
1,2-Dichloroethane	<1.0
1,1-Dichloroethene	<1.0
cis-1,2-Dichloroethene	<1.0
trans-1,2-Dichloroethene	<1.0
1,2-Dichloropropane	<1.0

Constituent	µg/l
cis-1,3-Dichloropropene	<1.0
trans-1,3-Dichloropropene	<1.0
Ethylbenzene	<1.0
2-Hexanone	<20
Iodomethane	<1.0
4-Methyl-2-pentanone (MIBK)	<20
Methylene chloride (Dichloromethane)	<1.0
Styrene	<1.0
Tetrachloroethene (Tetrachloroethylene)	<1.0
1,1,1,2-Tetrachloroethane	<1.0
1,1,2,2-Tetrachloroethane	<1.0
1,1,1-Trichloroethane	<1.0
1,1,2-Trichloroethane	<1.0
Trichloroethene (Trichloroethylene)	<1.0
Trichlorofluoromethane	<1.0
1,2,3-Trichloropropane	<1.0
Toluene	<1.0
Vinyl acetate	<1.0
Vinyl chloride (chloroethene)	<1.0
Xylenes:	<1.0
M	
P	
O	
trans-1,4-Dichloro-2-Butene	<1.0
Dichlorodifluoromethane	<1.0

NOTE: Method 8260 is the capillary equivalent to Method 8240.

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: 93-42565
DATE: 10/11/93 jmw

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WATER ANALYSIS

Laurel Landfill
993LAU001 MW-4
Sampled 09/10/93 @ 0711
Submitted 09/13/93

Constituent	mg/l (ppm)		Date Analyzed
Sulfate	5430		09/15/93
Chloride	99		09/15/93
Specific Conductance @ 25°C	8380	µmhos/cm	09/14/93
pH	7.1	s.u.	09/14/93
Chemical Oxygen Demand	14		09/14/93
Nitrate as N	1.70		09/17/93
Total Cyanide	<0.005		09/14/93
Dissolved Metals			
Antimony	<0.05		09/30/93
Arsenic	<0.005		09/23/93
Barium	<0.1		09/14/93
Beryllium	<0.001		09/14/93
Cadmium	<0.001		09/21/93
Chromium	0.01		09/15/93
Cobalt	<0.01		09/14/93
Copper	<0.01		09/14/93
Iron	<0.03		09/15/93
Lead	<0.01		09/15/93
Mercury	<0.001		09/13/93
Nickel	0.01		09/15/93
Selenium	0.018		09/13/93
Silver	<0.005		09/14/93
Thallium	<0.1		09/20/93
Vanadium	<0.10		09/14/93
Zinc	0.01		09/14/93

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: 93-42566
DATE: 10/11/93 jmw

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WATER ANALYSIS

Laurel Landfill
993LAU002 mw-3
Sampled 09/10/93 @ 1010
Submitted 09/13/93

Constituent	mg/l (ppm)		Date Analyzed
Sulfate	22700		09/15/93
Chloride	351		09/15/93
Specific Conductance @ 25°C	33700	µmhos/cm	09/14/93
pH	7.5	s.u.	09/14/93
Chemical Oxygen Demand	10		09/14/93
Nitrate as N	0.46		09/17/93
Total Cyanide	<0.005		09/14/93
Dissolved Metals			
Antimony	<0.35*		09/30/93
Arsenic	<0.025*		09/29/93
Barium	<0.1		09/14/93
Beryllium	<0.001		09/14/93
Cadmium	0.001		09/15/93
Chromium	<0.01		09/15/93
Cobalt	<0.01		09/14/93
Copper	0.16		09/14/93
Iron	0.12		09/14/93
Lead	0.03		09/15/93
Mercury	<0.001		09/13/93
Nickel	<0.01		09/15/93
Selenium	<0.005		09/13/93
Silver	<0.005		09/14/93
Thallium	<0.1		09/21/93
Vanadium	<0.10		09/14/93
Zinc	0.08		09/14/93

*Detection limit raised due to matrix interference.

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: 93-42567
DATE: 10/11/93 jmw

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WATER ANALYSIS

Laurel Landfill
993LAU003 MW-1
Sampled 09/10/93 @ 1303
Submitted 09/13/93

Constituent	mg/l (ppm)		Date Analyzed
Sulfate	24700		09/15/93
Chloride	190		09/15/93
Specific Conductance @ 25°C	27400	µmhos/cm	09/14/93
pH	6.7	s.u.	09/14/93
Chemical Oxygen Demand	47		09/14/93
Nitrate as N	0.07		09/21/93
Total Cyanide	<0.005		09/14/93
Dissolved Metals			
Antimony	<0.05		09/30/93
Arsenic	0.08		09/29/93
Barium	<0.1		09/15/93
Beryllium	<0.001		09/15/93
Cadmium	<0.001		09/15/93
Chromium	0.03		09/15/93
Cobalt	0.04		09/15/93
Copper	<0.01		09/15/93
Iron	<0.03		09/15/93
Lead	<0.01		09/15/93
Mercury	<0.001		09/13/93
Nickel	0.05		09/16/93
Selenium	<0.005		09/13/93
Silver	<0.005		09/15/93
Thallium	<0.1		09/21/93
Vanadium	<0.10		09/15/93
Zinc	<0.01		09/15/93

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: 93-42568
DATE: 10/11/93 jmw

WATER ANALYSIS

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Laurel Landfill
993LAU004 Equip Rinsate
Sampled 09/10/93 @ 1440
Submitted 09/13/93

Constituent	mg/l (ppm)		Date Analyzed
Sulfate	1		09/15/93
Chloride	<1		09/15/93
Specific Conductance @ 25°C	3	µmhos/cm	09/14/93
pH	6.0	s.u.	09/14/93
Chemical Oxygen Demand	<1		09/14/93
Nitrate as N	<0.05		09/17/93
Total Cyanide	<0.005		09/14/93
Dissolved Metals			
Antimony	<0.05		09/30/93
Arsenic	<0.005		09/23/93
Barium	<0.1		09/14/93
Beryllium	<0.001		09/14/93
Cadmium	0.001		09/15/93
Chromium	<0.01		09/15/93
Cobalt	<0.01		09/14/93
Copper	<0.01		09/14/93
Iron	0.05		09/14/93
Lead	0.01		09/15/93
Mercury	<0.001		09/13/93
Nickel	<0.01		09/15/93
Selenium	<0.005		09/13/93
Silver	<0.005		09/14/93
Thallium	<0.1		09/21/93
Vanadium	<0.10		09/14/93
Zinc	0.02		09/14/93

ENERGY LABORATORIES

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: 93-42569
DATE: 10/11/93 jmw

WATER ANALYSIS

RECEIVED OCT 12 1993

Laurel Landfill
993LAU005 MW-2
Sampled 09/10/93 @ 1510
Submitted 09/13/93

Constituent	mg/l (ppm)		Date Analyzed
Sulfate	16900		09/16/93
Chloride	208		09/16/93
Specific Conductance @ 25°C	19600	µmhos/cm	09/14/93
pH	6.9	s.u.	09/14/93
Chemical Oxygen Demand	62		09/14/93
Nitrate as N	54.2		09/17/93
Total Cyanide	<0.005		09/14/93
Dissolved Metals			
Antimony	<0.05		09/30/93
Arsenic	<0.005		09/23/93
Barium	<0.1		09/15/93
Beryllium	<0.001		09/15/93
Cadmium	0.011		09/17/93
Chromium	0.02		09/15/93
Cobalt	<0.01		09/17/93
Copper	<0.01		09/15/93
Iron	<0.03		09/15/93
Lead	<0.01		09/17/93
Mercury	<0.001		09/13/93
Nickel	0.04		09/15/93
Selenium	<0.005		09/13/93
Silver	<0.005		09/15/93
Thallium	<0.1		09/21/93
Vanadium	<0.10		09/15/93
Zinc	<0.01		09/15/93

ENERGY LABORATORIES

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: 93-42570
DATE: 10/11/93 jmw

WATER ANALYSIS

RECEIVED OCT 12 1993

Laurel Landfill
993LAU006 DUP MW-2
Sampled 09/10/93 @ 1615
Submitted 09/13/93

Constituent	mg/l (ppm)		Date Analyzed
Sulfate	17000		09/16/93
Chloride	204		09/16/93
Specific Conductance @ 25°C	19400	µmhos/cm	09/14/93
pH	6.9	s.u.	09/14/93
Chemical Oxygen Demand	53		09/14/93
Nitrate as N	53.9		09/17/93
Total Cyanide	<0.005		09/14/93
Dissolved Metals			
Antimony	<0.1*		09/30/93
Arsenic	<0.005		09/23/93
Barium	<0.1		09/15/93
Beryllium	<0.001		09/15/93
Cadmium	<0.001		09/20/93
Chromium	0.02		09/15/93
Cobalt	<0.01		09/17/93
Copper	<0.01		09/15/93
Iron	<0.03		09/15/93
Lead	<0.01		09/15/93
Mercury	<0.001		09/13/93
Nickel	<0.01		09/17/93
Selenium	<0.005		09/13/93
Silver	<0.005		09/15/93
Thallium	<0.1		09/21/93
Vanadium	<0.10		09/15/93
Zinc	<0.01		09/15/93

*Detection limit raised due to matrix interference.

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.
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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: 93-42570 dup
DATE: 10/11/93 jmw

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QUALITY ASSURANCE - DUPLICATE ANALYSIS

Laurel Landfill
993LAU006 DUP MW-2
Sampled 09/10/93 @ 1615
Submitted 09/13/93

Constituent	mg/l (ppm)		Date Analyzed
Sulfate	17100		09/16/93
Chloride	203		09/16/93
Specific Conductance @ 25°C	19300	μmhos/cm	09/14/93
pH	6.8	s.u.	09/14/93
Chemical Oxygen Demand	54		09/14/93
Nitrate as N	55.4		09/17/93
Total Cyanide	<0.005		09/14/93
Dissolved Metals			
Antimony	<0.1*		09/30/93
Arsenic	<0.005		09/23/93
Barium	<0.1		09/15/93
Beryllium	<0.001		09/15/93
Cadmium	<0.001		09/20/93
Chromium	0.02		09/15/93
Cobalt	<0.01		09/20/93
Copper	<0.01		09/15/93
Iron	<0.03		09/15/93
Lead	<0.01		09/15/93
Mercury	<0.001		09/13/93
Nickel	<0.01		09/17/93
Selenium	<0.005		09/13/93
Silver	<0.005		09/15/93
Thallium	<0.1		09/21/93
Vanadium	<0.10		09/15/93
Zinc	<0.01		09/15/93

*Detection limit raised due to matrix interference.

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FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: 93-43727
DATE: 10/15/93 jmw

RECEIVED OCT 18 1993

WATER ANALYSIS

Laurel Landfill, Laurel, MT
93LAU007 93mw-20
Sampled 09/21/93 @ 1814
Submitted 09/22/93

Constituent	mg/l (ppm)	Date Analyzed
Sulfate	111	09/28/93
Chloride	3300	09/28/93
Nitrate as N	0.19	09/29/93
Specific Conductance @ 25°C	11600 µmhos/cm	09/23/93
pH	8.1 s.u.	09/23/93
Chemical Oxygen Demand	<1	09/28/93
Total Cyanide	<0.005	09/23/93
Dissolved Metals		
Antimony	<0.05	09/30/93
Arsenic	0.020	09/29/93
Barium	0.7	09/23/93
Beryllium	0.003	09/23/93
Cadmium	0.001	09/27/93
Chromium	<0.01	09/23/93
Cobalt	<0.01	09/23/93
Copper	0.09	09/23/93
Iron	2.37	09/23/93
Lead	0.04	09/23/93
Mercury	<0.001	09/27/93
Nickel	0.02	09/23/93
Selenium	<0.005	09/28/93
Silver	<0.005	09/23/93
Thallium	<0.01	10/04/93
Vanadium	<0.10	09/23/93
Zinc	1.41	09/23/93

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: Blank
DATE: 10/11/93 jmw

WATER ANALYSIS

Method Blank #1
Analyzed 09/20/93

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PURGEABLE ORGANICS
EPA METHOD 8260 - LONG LIST

Constituent	μg/l
Acetone	<20
Acrylonitrile	<20
Benzene	<1.0
Bromochloromethane	<1.0
Bromodichloromethane	<1.0
Bromoform	<1.0
Bromomethane	<1.0
2-Butanone (Methyl Ethyl Ketone)	<20
Carbon disulfide	<1.0
Carbon tetrachloride	<1.0
Chlorobenzene	<1.0
Chlorodibromomethane	<1.0
Chloroethane	<1.0
Chloroform	<1.0
Chloromethane	<1.0
1,2-Dibromo-3-chloropropane (DBCP)	<1.0
1,2-Dibromoethane (EDB)	<1.0
Dibromomethane	<1.0
1,2-Dichlorobenzene	<1.0
1,4-Dichlorobenzene	<1.0
1,1-Dichloroethane	<1.0
1,2-Dichloroethane	<1.0
1,1-Dichloroethene	<1.0
cis-1,2-Dichloroethene	<1.0
trans-1,2-Dichloroethene	<1.0
1,2-Dichloropropane	<1.0
cis-1,3-Dichloropropene	<1.0
trans-1,3-Dichloropropene	<1.0
Ethylbenzene	<1.0
2-Hexanone	<20
Iodomethane	<1.0
4-Methyl-2-pentanone (MIBK)	<20
Methylene chloride (Dichloromethane)	<1.0
Styrene	<1.0
Tetrachloroethene (Tetrachloroethylene)	<1.0
1,1,1,2-Tetrachloroethane	<1.0
1,1,2,2-Tetrachloroethane	<1.0
1,1,1-Trichloroethane	<1.0
1,1,2-Trichloroethane	<1.0
Trichloroethene (Trichloroethylene)	<1.0
Trichlorofluoromethane	<1.0
1,2,3-Trichloropropane	<1.0
Toluene	<1.0
Vinyl acetate	<1.0
Vinyl chloride (chloroethene)	<1.0
Xylenes: M P O	<1.0
trans-1,4-Dichloro-2-Butene	<1.0

Method 8260 is the capillary equivalent to Method 8240.

ENERGY LABORATORIES

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FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: Blank
DATE: 10/11/93 jmw

WATER ANALYSIS

Method Blank #2
Analyzed 09/21/93

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PURGEABLE ORGANICS
EPA METHOD 8260 - LONG LIST

Constituent	µg/l
Acetone	<20
Acrylonitrile	<20
Benzene	<1.0
Bromochloromethane	<1.0
Bromodichloromethane	<1.0
Bromoform	<1.0
Bromomethane	<1.0
2-Butanone (Methyl Ethyl Ketone)	<20
Carbon disulfide	<1.0
Carbon tetrachloride	<1.0
Chlorobenzene	<1.0
Chlorodibromomethane	<1.0
Chloroethane	<1.0
Chloroform	<1.0
Chloromethane	<1.0
1,2-Dibromo-3-chloropropane (DBCP)	<1.0
1,2-Dibromoethane (EDB)	<1.0
Dibromomethane	<1.0
1,2-Dichlorobenzene	<1.0
1,4-Dichlorobenzene	<1.0
1,1-Dichloroethane	<1.0
1,2-Dichloroethane	<1.0
1,1-Dichloroethene	<1.0
cis-1,2-Dichloroethene	<1.0
trans-1,2-Dichloroethene	<1.0
1,2-Dichloropropane	<1.0
cis-1,3-Dichloropropene	<1.0
trans-1,3-Dichloropropene	<1.0
Ethylbenzene	<1.0
2-Hexanone	<20
Iodomethane	<1.0
4-Methyl-2-pentanone (MIBK)	<20
Methylene chloride (Dichloromethane)	<1.0
Styrene	<1.0
Tetrachloroethene (Tetrachloroethylene)	<1.0
1,1,1,2-Tetrachloroethane	<1.0
1,1,2,2-Tetrachloroethane	<1.0
1,1,1-Trichloroethane	<1.0
1,1,2-Trichloroethane	<1.0
Trichloroethene (Trichloroethylene)	<1.0
Trichlorofluoromethane	<1.0
1,2,3-Trichloropropane	<1.0
Toluene	<1.0
Vinyl acetate	<1.0
Vinyl chloride (chloroethene)	<1.0
Xylenes:	<1.0
M	
P	
O	
trans-1,4-Dichloro-2-Butene	<1.0

Method 8260 is the capillary equivalent to Method 8240.

ENERGY LABORATORIES

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LABORATORY REPORT

TO:	Margaret Hofacker	LAB NO.:	Blank
ADDRESS:	GeoResearch, Inc. 115 N. Broadway Billings, MT 59101	DATE:	10/11/93 jmw

WATER ANALYSIS

Method Blank #3
Analyzed 09/22/93

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Constituent	µg/l
PURGEABLE ORGANICS EPA METHOD 8260 - LONG LIST	
Acetone	<20
Acrylonitrile	<20
Benzene	<1.0
Bromochloromethane	<1.0
Bromodichloromethane	<1.0
Bromoform	<1.0
Bromomethane	<1.0
2-Butanone (Methyl Ethyl Ketone)	<20
Carbon disulfide	<1.0
Carbon tetrachloride	<1.0
Chlorobenzene	<1.0
Chlorodibromomethane	<1.0
Chloroethane	<1.0
Chloroform	<1.0
Chloromethane	<1.0
1,2-Dibromo-3-chloropropane (DBCP)	<1.0
1,2-Dibromoethane (EDB)	<1.0
Dibromomethane	<1.0
1,2-Dichlorobenzene	<1.0
1,4-Dichlorobenzene	<1.0
1,1-Dichloroethane	<1.0
1,2-Dichloroethane	<1.0
1,1-Dichloroethene	<1.0
cis-1,2-Dichloroethene	<1.0
trans-1,2-Dichloroethene	<1.0
1,2-Dichloropropane	<1.0

Constituent	µg/l
cis-1,3-Dichloropropene	<1.0
trans-1,3-Dichloropropene	<1.0
Ethylbenzene	<1.0
2-Hexanone	<20
Iodomethane	<1.0
4-Methyl-2-pentanone (MIBK)	<20
Methylene chloride (Dichloromethane)	<1.0
Styrene	<1.0
Tetrachloroethene (Tetrachloroethylene)	<1.0
1,1,1,2-Tetrachloroethane	<1.0
1,1,2,2-Tetrachloroethane	<1.0
1,1,1-Trichloroethane	<1.0
1,1,2-Trichloroethane	<1.0
Trichloroethene (Trichloroethylene)	<1.0
Trichlorofluoromethane	<1.0
1,2,3-Trichloropropane	<1.0
Toluene	<1.0
Vinyl acetate	<1.0
Vinyl chloride (chloroethene)	<1.0
Xylenes:	<1.0
M	
P	
O	
trans-1,4-Dichloro-2-Butene	<1.0

Method 8260 is the capillary equivalent to Method 8240.

ENERGY LABORATORIES

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: 93-42565-70
DATE: 10/11/93 jmw

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EPA WATER QUALITY CONTROL REFERENCE SAMPLE

Volatile Organic Compounds

This EPA Quality Control Sample was analyzed on 09/21/93 with your lab numbers with the following results:

Parameter	Spike Amount, µg/l	P (%)	Range for P (%)
Benzene	5.0	98	60-140
Bromodichloromethane	5.0	96	60-140
Bromoform	5.0	94	60-140
Chloroform	5.0	96	60-140
Dibromochloromethane	5.0	96	60-140
1,2-Dichlorobenzene	5.0	100	60-140
1,1-Dichloroethane	5.0	94	60-140
Methylene Chloride	5.0	100	60-140
1,1,2,2-Tetrachloroethane	5.0	94	60-140
Toluene	5.0	96	60-140
1,1,1-Trichloroethane	5.0	98	60-140
Trichloroethene	5.0	100	60-140

P = Percent recovery measured.

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: 93-42565-70
DATE: 10/11/93 jmw

WATER VOLATILE SURROGATE RECOVERY

RECEIVED OCT 12 1993

	------% recovery------		
SAMPLE NO.	S1 (TOL)	S2 (BFB)	S3 (DCE)
93-42565⁽¹⁾	95	96	110
93-42566⁽¹⁾	99	94	105
93-42567⁽¹⁾	98	96	104
93-42568⁽²⁾	100	103	93
93-42569⁽²⁾	98	96	97
93-42570⁽²⁾	95	93	106
Blank #1⁽²⁾	99	103	96
Blank #2⁽²⁾	99	97	97
Blank #3⁽²⁾	100	101	98

	QC LIMITS, % Recovery
S1 (TOL) = Toluene-d8	80-120
S2 (BFB) = Bromofluorobenzene	80-120
S3 (DCE) = 1,2-Dichloroethane-d4	80-120

(1) 20 μg/l Surrogate Standard Spike

(2) 10 μg/l Surrogate Standard Spike

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LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: Blank
DATE: 10/15/93 jmw

RECEIVED OCT 18 1993

WATER ANALYSIS

Method Blank
Analyzed 10/05/93

Constituent	µg/l
PURGEABLE ORGANICS EPA METHOD 8260 - LONG LIST	
Acetone	<20
Acrylonitrile	<20
Benzene	<1.0
Bromochloromethane	<1.0
Bromodichloromethane	<1.0
Bromoform	<1.0
Bromomethane	<1.0
2-Butanone (Methyl Ethyl Ketone)	<20
Carbon disulfide	<1.0
Carbon tetrachloride	<1.0
Chlorobenzene	<1.0
Chlorodibromomethane	<1.0
Chloroethane	<1.0
Chloroform	<1.0
Chloromethane	<1.0
1,2-Dibromo-3-chloropropane (DBCP)	<1.0
1,2-Dibromoethane (EDB)	<1.0
Dibromomethane	<1.0
1,2-Dichlorobenzene	<1.0
1,4-Dichlorobenzene	<1.0
1,1-Dichloroethane	<1.0
1,2-Dichloroethane	<1.0
1,1-Dichloroethene	<1.0
cis-1,2-Dichloroethene	<1.0
trans-1,2-Dichloroethene	<1.0
1,2-Dichloropropane	<1.0
cis-1,3-Dichloropropene	<1.0
trans-1,3-Dichloropropene	<1.0
Ethylbenzene	<1.0
2-Hexanone	<20
Iodomethane	<1.0
4-Methyl-2-pentanone (MIBK)	<20
Methylene chloride (Dichloromethane)	<1.0
Styrene	<1.0
Tetrachloroethene (Tetrachloroethylene)	<1.0
1,1,1,2-Tetrachloroethane	<1.0
1,1,2,2-Tetrachloroethane	<1.0
1,1,1-Trichloroethane	<1.0
1,1,2-Trichloroethane	<1.0
Trichloroethene (Trichloroethylene)	<1.0
Trichlorofluoromethane	<1.0
1,2,3-Trichloropropane	<1.0
Toluene	<1.0
Vinyl acetate	<1.0
Vinyl chloride (chloroethene)	<1.0
Xylenes:	<1.0
M	
P	
O	
trans-1,4-Dichloro-2-Butene	<1.0

Method 8260 is the capillary equivalent to Method 8240.

ENERGY LABORATORIES

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FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: Margaret Hofacker
ADDRESS: GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

LAB NO.: 93-43727
DATE: 10/15/93 jmw

RECEIVED OCT 18 1993

WATER VOLATILE SURROGATE RECOVERY

10 μg/l Surrogate Standard Spike

SAMPLE NO.	S1 (TOL)	S2 (BFB)	S3 (DCE)
	------% recovery------		
93-43727	112	107	99
Blank	111	105	105

S1 (TOL) = Toluene-d8
S2 (BFB) = Bromofluorobenzene
S3 (DCE) = 1,2-Dichloroethane-d4

QC LIMITS, % Recovery
80-120
80-120
80-120

ENERGY LABORATORIES, INC.
P.O. Box 30916 1107 South Broadway
Billings, MT 59107

toll-free 800-735-4489
voice 406-252-6325
fax 406-252-6069

CHAIN OF CUSTODY RECORD

PLEASE PRINT OR TYPE ALL INFORMATION EXCEPT SIGNATURES

P.O. # 112035

Project Name / Address: Laurel Landfill

Contact Name & Phone: Margaret Hofacker GeoResearch 248-6771

Sampler's signature: Margaret M. Hofacker

Invoice to:
Geo Research, Inc.
115 N. Broadway
Billings, MT 59101

Report to:
Margaret Hofacker
Geo Research, Inc.

DATE	TIME	composite	grab sample	SAMPLE I.D.	number of containers / Sample Type: A W S V U O (Air Water Soils/solids Vegetation Urine Other)	Analysis Requested: Solid Waste Table 1	VOC long list	Nitrate & COD	Cyanide	Minerals & Parameters Cl^- SO_4 pH &	Dissolved Metals				Comments, Special Instructions, etc.
9/10/93	0711		X	993 LAU 001	6 W	X	X	X	X	X					
	1010			993 LAU 002	6 W	X	X	X	X	X					
	1303			993 LAU 003	6 W	X	X	X	X	X					
	1440			993 LAU 004	6 W	X	X	X	X	X					
	1510			993 LAU 005	6 W	X	X	X	X	X					
↓	1615		↓	993 LAU 006	6 W	X	X	X	X	X					

1. Relinquished (signature)	Date	Time	Received by: (signature)	3. Relinquished (signature)	Date	Time	Received by (signature):
Margaret M. Hofacker	9/10/93	1738					
2. Relinquished (signature)	**Date**	**Time**	**Received by: (signature)**	**4. Relinquished (signature)**	**Date**	**Time**	**Received for laboratory by (signature):**
							Pat [illegible]

ENERGY LABORATORIES, INC.
P.O. Box 30916 1107 South Broadway
Billings, MT 59107

toll-free 800-735-4489
voice 406-252-6325
fax 406-252-6069

CHAIN OF CUSTODY RECORD

PLEASE PRINT OR TYPE ALL INFORMATION EXCEPT SIGNATURES

P.O. #: 112035

Project Name / Address: Laurel Landfill
Laurel MT

Contact Name & Phone: Margaret Hofacker
244-6771

Sampler's signature: Margaret M. Hofacker

Invoice to:
GeoResearch, Inc.
115 N. Broadway
Billings, MT 59101

Report to:
Margaret Hofacker
GeoResearch, Inc
115 N. Broadway
Billings MT 59101

Analysis Requested: MT SWP Table I

DATE	TIME	composite	grab sample	SAMPLE I.D.	number of containers	Sample Type: A W S V U O Air Water Soils/solids Vegetation Urine Other	VOC - long list 2-40mL vials, H	Nitrate, COD, 250 ml plastic, H_2SO_4	Cyanide 500 ml plastic, NaOH	Cl^- SO_4, pH, Sc 500 ml plastic	Dissolved metals, 250 ml plastic HNO_3, Filtered				Comments, Special Instructions, etc.
9/21/93	1814		X	93LAU007	6	W	2	1	1	1	1				Montana SWP Table I

1. Relinquished (signature)	Date	Time	Received by: (signature)	3. Relinquished (signature)	Date	Time	Received by (signature):
Margaret M. Hofacker	9/22/93	0924					

2. Relinquished (signature)	Date	Time	Received by: (signature)	4. Relinquished (signature)	Date	Time	Received for laboratory by (signature):
					09/22/93	0924	Landa Hoelscher

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Box 17

Green folder and all contents within	SWS-CL-338	Main	NA	City of Big Timber Landfill	308	Montana Department of Environmental Quality	English	Class II Landfill; Closed; Closure; Post-Closure; Groundwater; Soil; Sediment; Leachate; Vapor; Reclamation; Solid Waste; Landfill
Green folder and all contents within	SWS-CL-339	Closure/Post-Closure	NA	City of Big Timber Landfill	308	Montana Department of Environmental Quality	English	Class II Landfill; Closed; Closure; Post-Closure; Groundwater; Soil; Sediment; Leachate; Vapor; Reclamation; Solid Waste; Landfill
Green folder and all contents within	SWS-CL-340	Closure/Post-Closure FA	NA	City of Big Timber Landfill	308	Montana Department of Environmental Quality	English	Class II Landfill; Closed; Closure; Post-Closure; Groundwater; Soil; Sediment; Leachate; Vapor; Reclamation; Solid Waste; Landfill
Green folder and all contents within	SWS-CL-341	Groundwater Monitoring 1991-1996	1991	City of Big Timber Landfill	308	Montana Department of Environmental Quality	English	Class II Landfill; Closed; Closure; Post-Closure; Groundwater; Soil; Sediment; Leachate; Vapor; Reclamation; Solid Waste; Landfill
Green folder and all contents within	SWS-CL-342	Groundwater Monitoring 1997-1999	1997	City of Big Timber Landfill	308	Montana Department of Environmental Quality	English	Class II Landfill; Closed; Closure; Post-Closure; Groundwater; Soil; Sediment; Leachate; Vapor; Reclamation; Solid Waste; Landfill
Green folder and all contents within	SWS-CL-343	Groundwater Monitoring 2000-	2000	City of Big Timber Landfill	308	Montana Department of Environmental Quality	English	Class II Landfill; Closed; Closure; Post-Closure; Groundwater; Soil; Sediment; Leachate; Vapor; Reclamation; Solid Waste; Landfill
Green folder and all contents within	SWS-CL-344	Hydrology Report 1990	1990	City of Big Timber Landfill	308	Montana Department of Environmental Quality	English	Class II Landfill; Closed; Closure; Post-Closure; Groundwater; Soil; Sediment; Leachate; Vapor; Reclamation; Solid Waste; Landfill
Green folder and all contents within	SWS-CL-345	Inspections	NA	City of Big Timber Landfill	308	Montana Department of Environmental Quality	English	Class II Landfill; Closed; Closure; Post-Closure; Groundwater; Soil; Sediment; Leachate; Vapor; Reclamation; Solid Waste; Landfill
Green folder and all contents within	SWS-CL-346	Liner/Leachate	NA	City of Big Timber Landfill	308	Montana Department of Environmental Quality	English	Class II Landfill; Closed; Closure; Post-Closure; Groundwater; Soil; Sediment; Leachate; Vapor; Reclamation; Solid Waste; Landfill
Green folder and all contents within	SWS-CL-347	Methane Monitoring	NA	City of Big Timber Landfill	308	Montana Department of Environmental Quality	English	Class II Landfill; Closed; Closure; Post-Closure; Groundwater; Soil; Sediment; Leachate; Vapor; Reclamation; Solid Waste; Landfill
Green folder and all contents within	SWS-CL-348	Operation and Maintenance Plan	NA	City of Big Timber Landfill	308	Montana Department of Environmental Quality	English	Class II Landfill; Closed; Closure; Post-Closure; Groundwater; Soil; Sediment; Leachate; Vapor; Reclamation; Solid Waste; Landfill
Green folder and all contents within	SWS-CL-349	Run-on/Run-off	NA	City of Big Timber Landfill	308	Montana Department of Environmental Quality	English	Class II Landfill; Closed; Closure; Post-Closure; Groundwater; Soil; Sediment; Leachate; Vapor; Reclamation; Solid Waste; Landfill
Green folder and all contents within	SWS-CL-350	Main	NA	Laurel Landfill	203	Montana Department of Environmental Quality	English	Class II Landfill; Closed; Closure; Post-Closure; Groundwater; Soil; Sediment; Leachate; Vapor; Reclamation; Solid Waste; Landfill
Green folder and all contents within	SWS-CL-351	Closure/Post-Closure	NA	Laurel Landfill	203	Montana Department of Environmental Quality	English	Class II Landfill; Closed; Closure; Post-Closure; Groundwater; Soil; Sediment; Leachate; Vapor; Reclamation; Solid Waste; Landfill
Green folder and all contents within	SWS-CL-352	Groundwater Monitoring 1992-1993	1992	Laurel Landfill	203	Montana Department of Environmental Quality	English	Class II Landfill; Closed; Closure; Post-Closure; Groundwater; Soil; Sediment; Leachate; Vapor; Reclamation; Solid Waste; Landfill
Green folder and all contents within	SWS-CL-353	Groundwater Monitoring 1994-1996	1994	Laurel Landfill	203	Montana Department of Environmental Quality	English	Class II Landfill; Closed; Closure; Post-Closure; Groundwater; Soil; Sediment; Leachate; Vapor; Reclamation; Solid Waste; Landfill
Green folder and all contents within	SWS-CL-354	Groundwater Reports	NA	Laurel Landfill	203	Montana Department of Environmental Quality	English	Class II Landfill; Closed; Closure; Post-Closure; Groundwater; Soil; Sediment; Leachate; Vapor; Reclamation; Solid Waste; Landfill

GEORESEARCH, INC.

HYDROGEOLOGICAL AND SOILS STUDY

AT THE CITY OF LAUREL LANDFILL

December 31, 1992

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MONTANA DEPARTMENT OF HEALTH
AND ENVIRONMENTAL SCIENCES
SOLID AND HAZARDOUS WASTE BUREAU

HYDROGEOLOGICAL AND SOILS STUDY

AT THE CITY OF LAUREL LANDFILL

Prepared for:

City of Laurel
P.O. Box 10
Laurel, Montana 59044

Prepared by:

GeoResearch, Inc.
115 North Broadway
Billings, Montana 59101
(406) 248-6771

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1.0 INTRODUCTION

This report presents the findings of GeoResearch's Hydrogeological and Soils Study at the existing Laurel landfill north of Laurel, Montana. This investigation was performed in response to a request by the State Solid Waste Program (SWP) dated May 8, 1992 concerning the status of the site. Among other tasks, the letter required the City to conduct a hydrogeological and soils study and to monitor ground water. The specific requirements for conducting the study are described in Subchapter 7 of Title 16, Chapter 14 of the Administrative Rules of Montana.

1.1 Scope of Work

GeoResearch submitted a work plan for conducting the investigation to the SWP dated September 4, 1992. Through a review and response process between SWP and GeoResearch, a final scope of work was defined. The work plan includes the following correspondence:

- Work Plan for a Hydrogeological and Soils Investigation
  at the City of Laurel Landfill
  Dated: September 4, 1992
  Prepared by: GeoResearch, Inc.

- Laurel Class II Landfill, Yellowstone County, License No. 203
  Review of the Workplan for the Hydrogeological and Soils Study
  Dated: October 6, 1992
  Prepared by: Solid Waste Program

- Response to Review of the Work Plan for the
  Hydrogeological and Soils Study
  Dated: October 14, 1992
  Prepared by: GeoResearch, Inc.

- Requirements for Approval of the Workplan for the
  Laurel Class II Landfill, Yellowstone County, License No. 203
  Dated: October 21, 1992
  Prepared by: Solid Waste Program

- Response to Comments Concerning the Work Plan for a
  Hydrogeological and Soils Investigation at the City of Laurel Landfill
  Dated: October 26, 1992
  Prepared by: GeoResearch, Inc.

- Approval of the Workplan for Laurel Landfill
  Yellowstone County, License No. 203
  Dated: October 26, 1992
  Prepared by: Solid Waste Program

This investigation included drilling of test borings, monitoring well construction and development, and hydraulic conductivity testing of aquifer and vadose zone materials, and collection and analysis of ground water samples.

Specifically, this additional investigation included:

- Drilling 4 test borings to ground water;
- Drilling 1 test boring for hydraulic conductivity testing;
- Hand-augering 3 borings for hydraulic conductivity testing;
- 6 laboratory tests on soil samples;
- Completing 4 monitoring wells;
- Completing 1 permeability test well;
- Developing the monitoring wells;
- Conducting 6 aquifer tests;
- Conducting 4 unsaturated permeability tests;
- Sampling and analyzing 6 ground water samples; and
- Compiling this report.

2.0 SITE DESCRIPTION

2.1 General Description

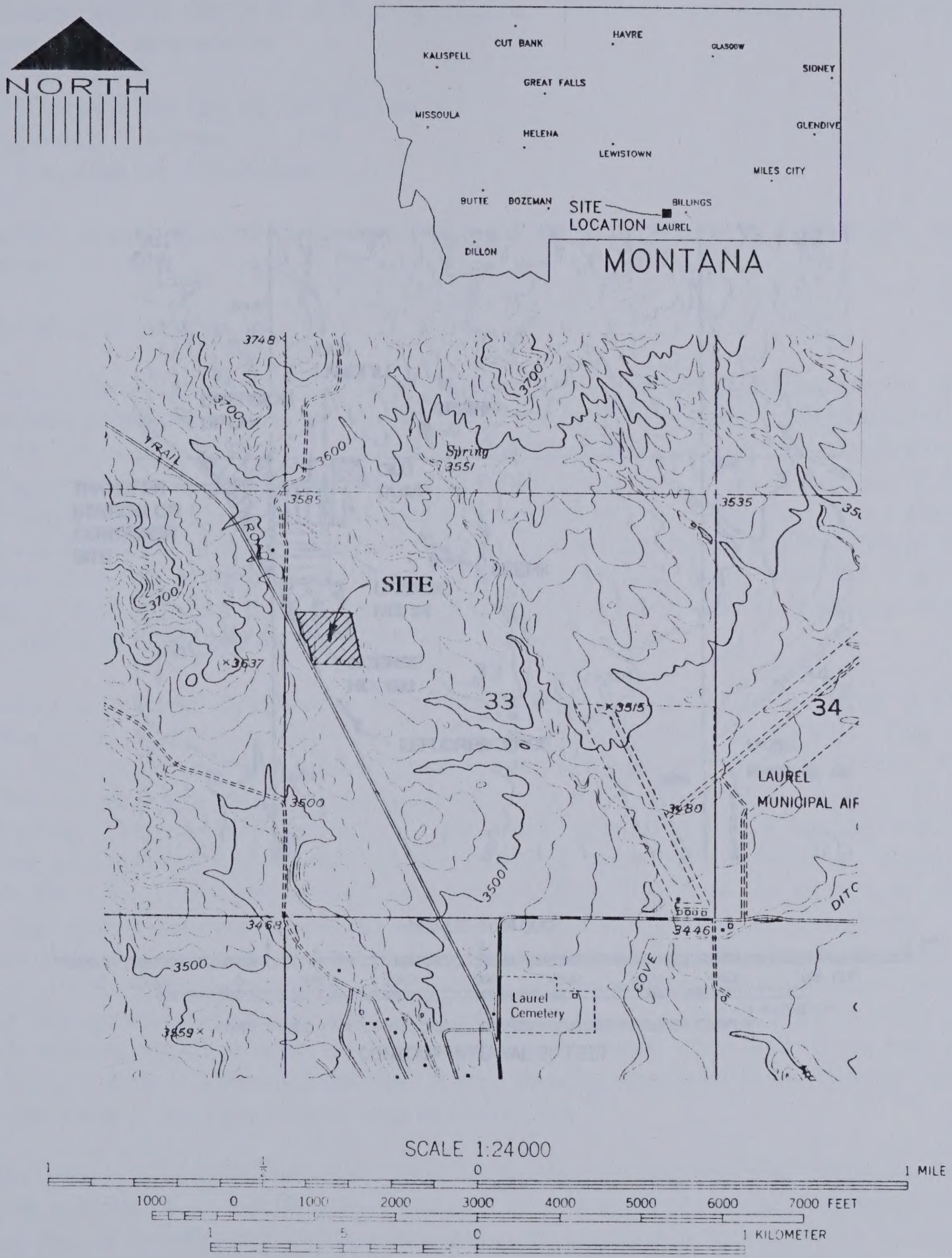
The landfill, located on Buffalo Trail (State Route 532) approximately one and one half mile north of Laurel, is owned by the Montana Department of State Lands and operated by the City of Laurel under a right-of-way easement. A vicinity map showing the location of the site is presented on Figure 2-1. The site consists of several adjacent parcels totaling approximately 40 acres. The present landfill consists of 10.02 acres located in the northwest quarter of Section 33, Township 1 South, Range 24 East. The present parcel was licensed in 1982 as an expansion to a ten acre site located in the northwest quarter of Section 33 which was licensed in 1978. This investigation specifically addresses the new site (License #203) which was in operation in October, 1989. The older site immediately to the north (License #24) was closed in 1983 and §75.10.204(5) MCA does not apply and an investigation of this site is not required.

According to file information obtained from SWP, a dump site was opened in 1965 in the vicinity of the other sites. This dump probably corresponds to two additional fill areas which were identified in the field. One site is located adjacent to the License #24 site and is bounded on the north side by a diversion ditch. This site has been covered and fenced and presently has a poor stand of grass on the cover. Northeast of these landfill sites along the north line of section 33 is a dump area which contains buried waste and a ridge of soil which may have been a stockpile of cover material or topsoil. The approximate relative locations of these sites are presented on Figure 2-2.

For the purposes of this report, "site" refers to the currently licensed (#203) 10.02 acre facility.

2.2 Site Topography

The site is located on colluvial uplands above the Yellowstone Valley. Prior to landfilling, the topography was gently sloping toward the southeast with shallow swales draining the central area of the site to a more defined swale which generally followed the east boundary and exited toward the southeast. The site is currently largely covered with waste to the boundaries. A drainage swale which drains a significant area is located along the north and east boundaries of an older landfill as shown in Figure 2-2. The older landfills have been graded to smooth, positively drained, gentle slopes with the highest points near the center. A final cover has been applied and vegetation has been established.



CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

GEO
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FIGURE 2 – 1

VICINITY MAP
CITY OF LAUREL LANDFILL
LAUREL, MONTANA

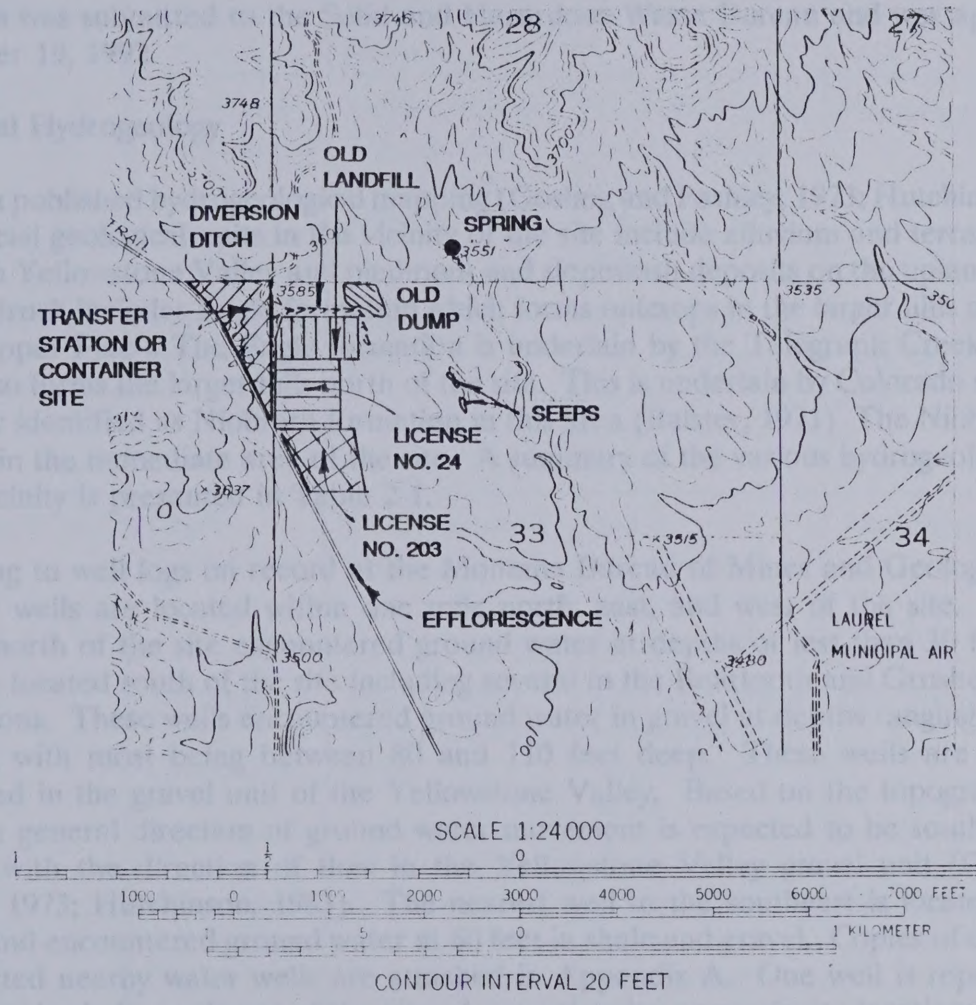

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FIGURE 2–2

GENERAL SITE MAP
CITY OF LAUREL LANDFILL
LAUREL, MONTANA

The current site is currently undergoing closure. Further information on site closure activities can be obtained in:

- Closure Plan, City of Laurel Landfill
  Dated: November 17, 1992
  Prepared by: GeoResearch, Inc.

This plan was submitted to the Solid and Hazardous Waste Bureau and was approved on November 19, 1992.

2.3 Areal Hydrogeology

Based on published hydrogeological mapping (Gosling and Pashley, 1973; Hutchinson, 1983), the surficial geological units in the vicinity of the site include alluvium and terrace deposits along the Yellowstone Valley and piedmont and slopewash deposits on the uplands near the site. Bedrock includes Eagle formation which forms outcrops in the larger hills north of the site (Clapper Flats). The Eagle formation is underlain by the Telegraph Creek formation which also forms the larger hills north of the site. This is underlain by Colorado shale which is further identified as Niobrara formation in this area (Balster, 1971) The Niobrara forms the hills in the immediate area of the site. A summary of the various hydrogeological units in the vicinity is presented in Table 2-1.

According to well logs on record at the Montana Bureau of Mines and Geology in Butte, very few wells are located within one mile north, east, and west of the site. Two wells located north of the site encountered ground water at depths of less than 30 feet. Many wells are located south of the site including several in the Beartooth and Groshelle Heights subdivisions. These wells encountered ground water in gravel at depths ranging from 40 to 150 feet with most being between 80 and 110 feet deep. These wells are apparently completed in the gravel unit of the Yellowstone Valley. Based on the topography of the area, the general direction of ground water movement is expected to be southeast. This concurs with the direction of flow in the Yellowstone Valley gravel unit (Gosling and Pashley, 1973; Hutchinson, 1983). The nearest well to the southeast is located near the airport and encountered ground water at 60 feet in shale and gravel. Copies of driller's logs for selected nearby water wells are attached in Appendix A. One well is reported to be completed in shale southwest of the site. A map showing approximate locations of some of the water wells in the area is presented in Figure 2-3.

On-site information indicates that some ground-water seepage was detected during excavation of trenches. Additionally, a spring is located north of the site, seepage areas are located east of the site, and an area containing efflorescence is located south of the site. The efflorescence is indicative of seepage of highly mineralized water. The locations of these areas are presented on Figure 2-2.

The entire site is currently undergoing closure. Further information on site closure activities can be obtained in:

- Closure Plan, City of Laurel Landfill
  Dated: November 17, 1992
  Prepared by: GeoResearch, Inc.

This plan was submitted to the Solid and Hazardous Waste Bureau and was approved on November 19, 1992.

2.3 Area Hydrogeology

Based on published hydrogeological mapping (Cushing and Pashley, 1973; Hutchinson, 1983), the surficial geological units in the vicinity of the site include alluvium and terrace deposits along the Yellowstone Valley and pediment and/or gravels deposits on the uplands near the site. Bedrock includes Eagle Formation which forms outcrops in the larger hills north of the site (Schipper, 1985). The Eagle formation is underlain by the Telegraph Creek formation which also forms the larger hills north of the site. This is underlain by Colorado Group which is further identified as Niobrara formation in the area (Moberly, 1975). The Niobrara forms the hills in the immediate area of the site. A summary of the various hydrogeologic units in the vicinity is presented in Table 2.1.

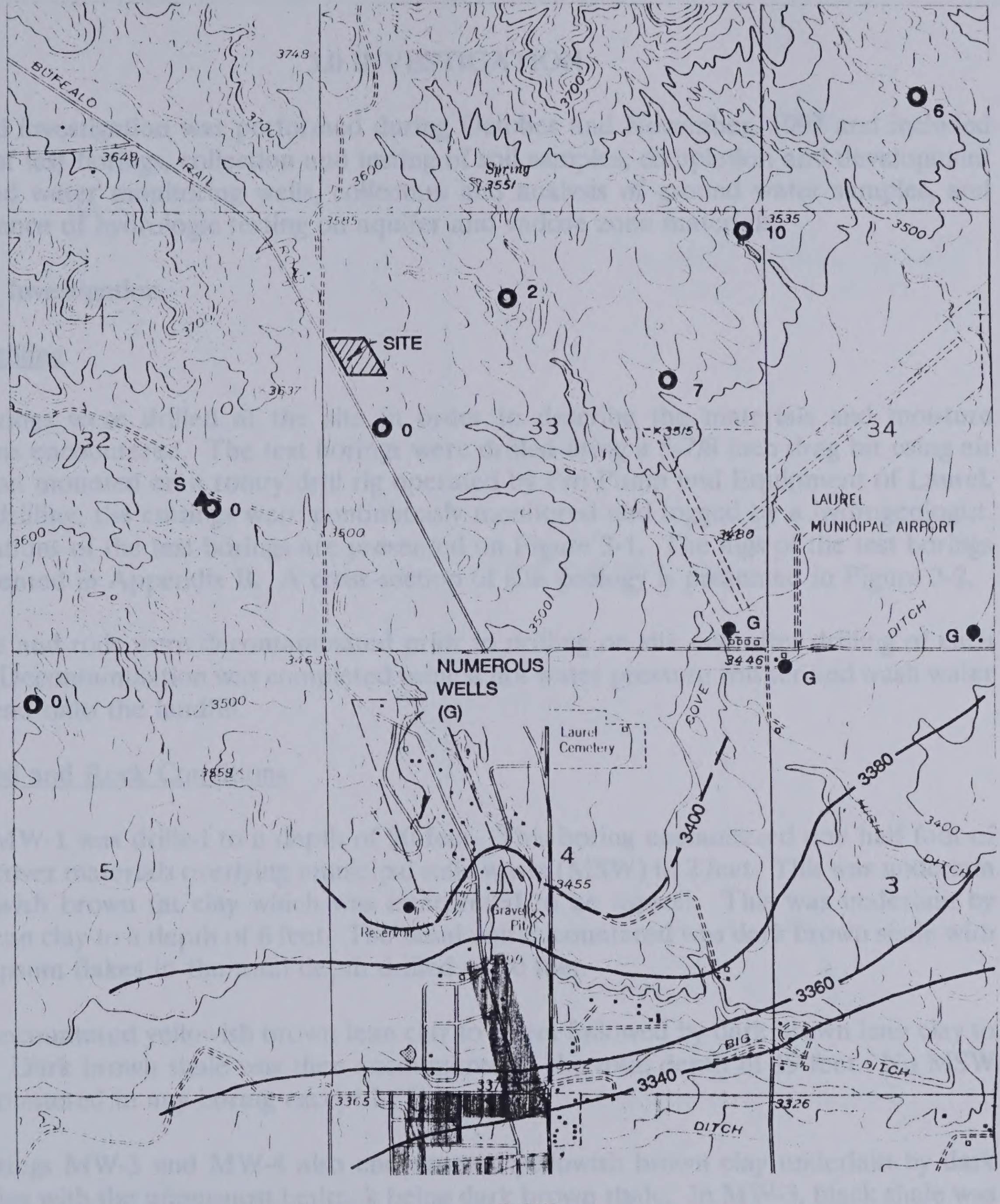
According to well logs on record at the Montana Bureau of Mines and Geology in Butte, very few wells are located within one mile north, east, and west of the site. Two wells located north of the site encountered ground water at depths of less than 50 feet. Many wells are located south of the site including several in the Donato and Cottonwood Heights subdivisions. These wells encountered ground water at reported depths ranging from 40 to 150 feet, with most being between 80 and 130 feet deep. These wells are apparently completed in the gravel unit of the Yellowstone Valley. Based on the topography of the area, the general direction of ground water movement is expected to be southeast. This is in concert with the direction of flow in the Yellowstone Valley ground fill (Cushing and Pashley, 1973; Hutchinson, 1983). The nearest well to the southeast is located near the airport and encountered ground water at 60 feet in shale and gravel. Copies of driller's logs for selected nearby water wells are presented in Appendix A. One well is reported to be completed in shale southwest of the site. A map showing approximate locations of some of the water wells in the area is presented in Figure 2.3.

Onsite information indicates that some ground-water seepage was detected during excavation of trenches. Additionally, a spring is located north of the site, seepage areas are located east of the site, and an area containing efflorescence is located south of the site. The efflorescence is indicative of seepage of highly mineralized water. The locations of these areas are presented on Figure 2.2.

TABLE 2-1
GENERALIZED DESCRIPTIONS OF PERTINENT HYDROGEOLOGICAL UNITS

Age	Geological Unit	Lithology	Water-Bearing Characteristic	Relevance to Site
Quaternary	Alluvium	Sand and Gravel	Good aquifer	Not present
	Slopewash Deposits	Sand, silt, and silty clay from Cretaceous rocks	Can yield small quantities of highly mineralized water	Present at site
Tertiary	Terrace deposits	Sand and gravel	Often dry, but can produce domestic quantities of water	Present north and west of site
Cretaceous	Eagle Formation	Sandstone and shale	Basal sandstone (Virgelle) is a major aquifer	Not present
	Telegraph Creek Formation	Thin-bedded sandstone and shale	Can yield small quantities of mineralized water	Not present
	Niobrara Formation (Colorado Shale)	Gray to black shale	Can yield small amounts of highly mineralized water	Uppermost bedrock at site
	Other Colorado Shale units	Gray to black shale, minor sandy units	Generally dry except in sandy units	Total thickness of Colorado is approximately 2000 feet.
	Kootenai Formation	Sandstone and siltstone	Yields oil, gas, or water	Recognized aquifer

Sources: Gosling and Pashley, 1973; Levings, 1981; Noble et al., 1982; Downey and Dinwiddie, 1988



LEGEND

G ● DOMESTIC WELL IN GRAVEL OR UNKNOWN AQUIFER

S ▲ STOCK WELL IN BLACK SHALE

6 O BORING WITH GEOLOGIST'S LOG REPORTED BY HUTCHINSON, 1983; THICKNESS, IN FEET, OF SAND AND GRAVEL ENCOUNTERED

3300 WATER-TABLE CONTOUR FOR AUGUST, 1978 FROM HUTCHINSON, 1983

NORTH

0' 1000' 2000' 4000'

SCALE: 1"=2000 FEET

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FIGURE 2-3

AREAL HYDROGEOLOGICAL MAP
CITY OF LAUREL LANDFILL

3.0 INVESTIGATION

The field investigation was performed during October and November, 1992 and included drilling of test borings, collection and testing of soil samples, completion and development of ground water monitoring wells, collection and analysis of ground water samples, and performance of hydrologic testing on aquifer and vadose zone materials.

3.1 Soil Investigation

3.1.1 Drilling

Test borings were drilled at the site in order to describe the materials and moisture conditions encountered. The test borings were drilled using a 5-7/8 inch drag bit using air circulation mounted on a rotary drill rig operated by Pro Pump and Equipment of Laurel. During drilling, the cuttings were continuously monitored and logged by a hydrogeologist. The locations of the test borings are presented on Figure 3-1. The logs of the test borings are presented in Appendix B. A cross-section of site geology is presented in Figure 3-2.

Drill bits and rods were decontaminated prior to drilling on site and after drilling of each boring. Decontamination was completed using a hot water pressure washer and wash water was spread onto the landfill.

3.1.2 Soil and Rock Conditions

Boring MW-1 was drilled to a depth of 20 feet. This boring encountered one half foot of fat clay cover materials overlying municipal solid waste (MSW) to 2 feet. This was underlain by yellowish brown fat clay which was interpreted to be topsoil. This was underlain by brown lean clay to a depth of 6 feet. The basal unit encountered was dark brown shale with some gypsum flakes to the total depth drilled of 20 feet.

MW-2 encountered yellowish brown lean clay to 3 feet followed by dark brown lean clay to 10 feet. Dark brown shale was then encountered to the total depth of 19 feet. No MSW was encountered in any boring except MW-1.

Test borings MW-3 and MW-4 also encountered yellowish brown clay underlain by dark brown clay with the uppermost bedrock being dark brown shale. In MW-3, black shale was encountered from a depth of 19 feet to the total depth drilled of 55 feet with a thin bed of hard gray shale at 35 to 36 feet. Similar conditions were encountered at MW-4 with black shale occurring from 27 to 32 feet with a very thin bed of hard gray shale at 27 feet.

R-1 was drilled to a total depth of 7 feet and encountered yellowish brown fat clay. G-1 and G-2 also encountered yellowish brown fat clay.

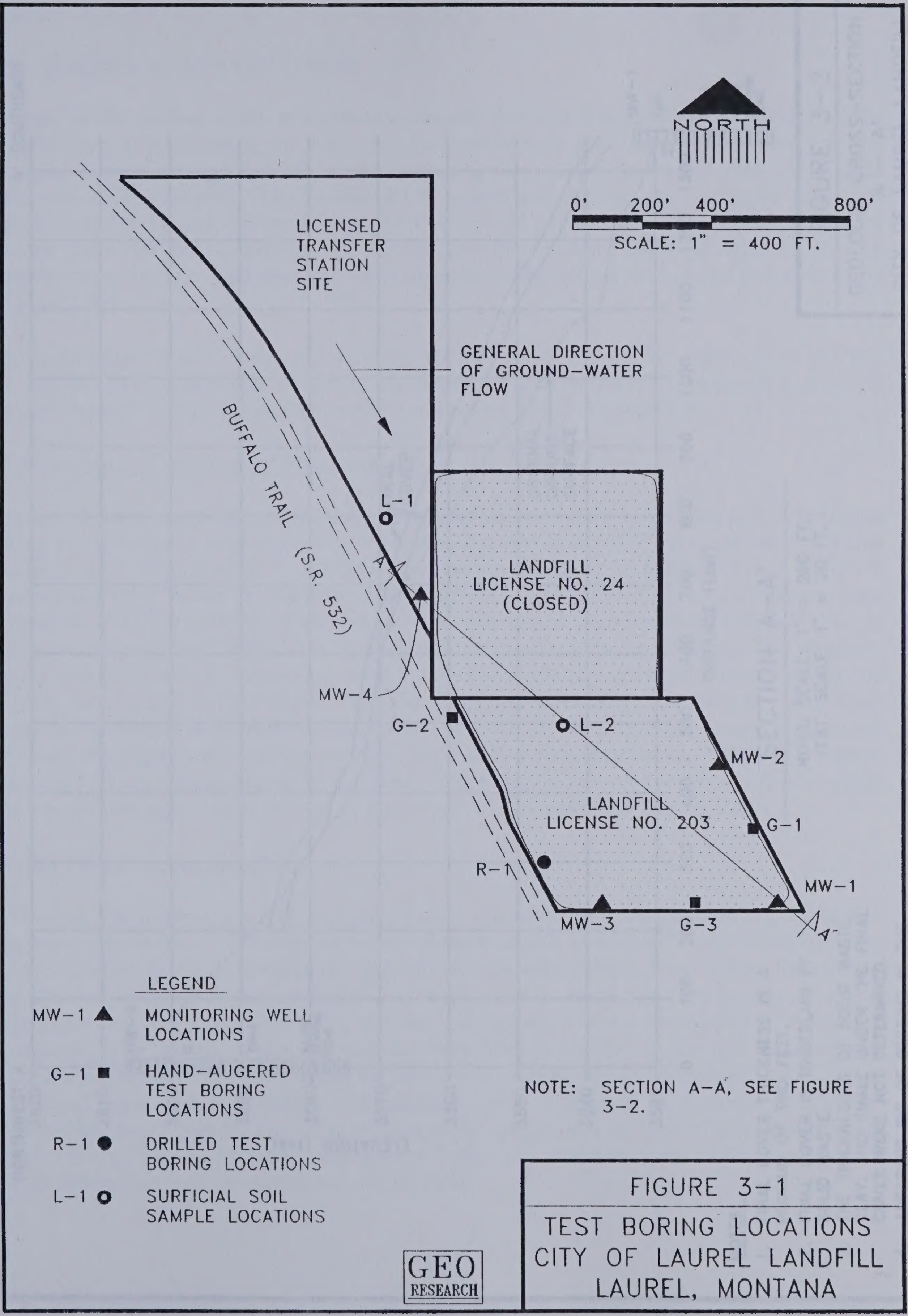
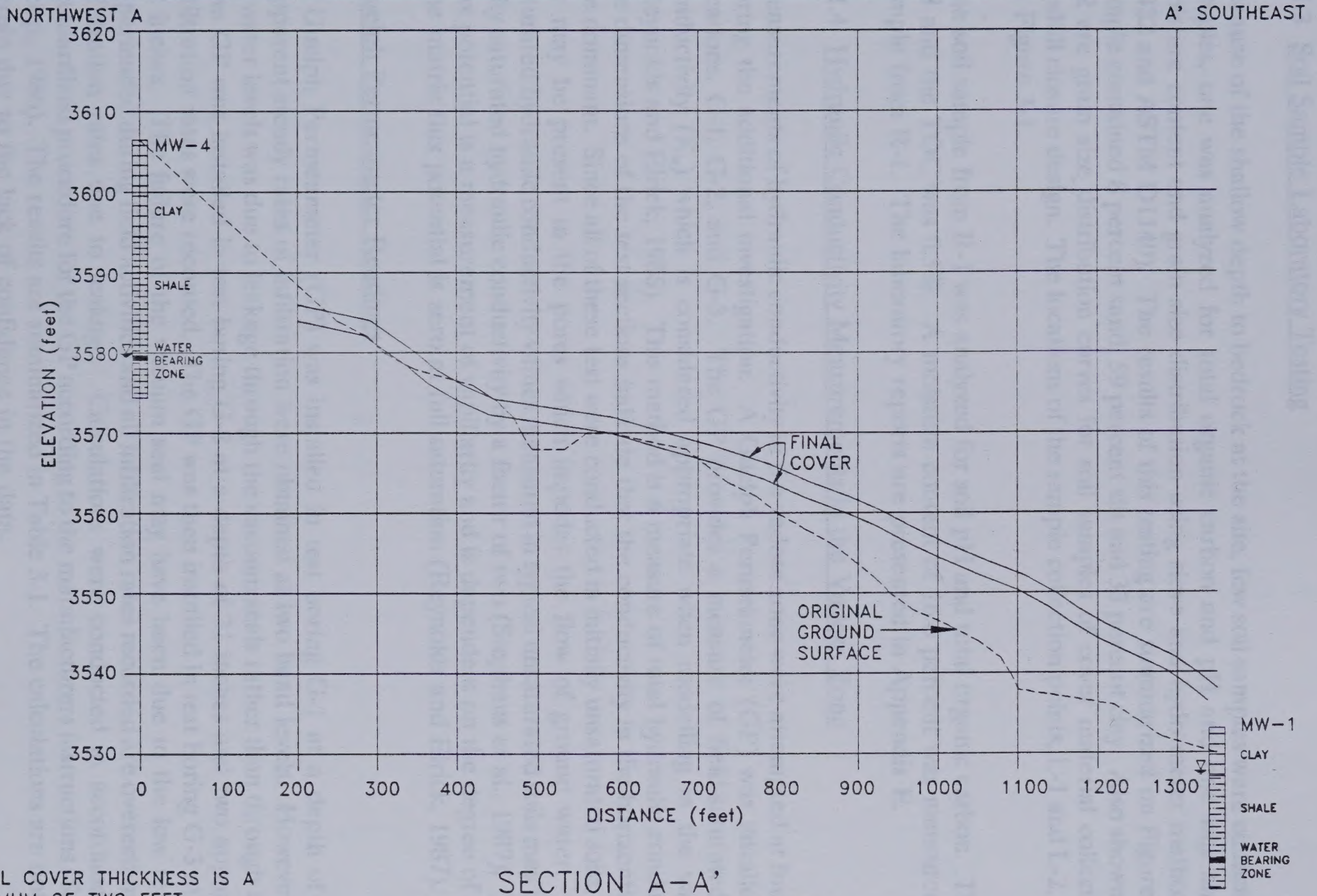

NORTH
0' 200' 400' 800'
SCALE: 1" = 400 FT.
LICENSED TRANSFER STATION SITE
GENERAL DIRECTION OF GROUND-WATER FLOW
BUFFALO TRAIL (S.R. 532)
L-1
A
LANDFILL LICENSE NO. 24 (CLOSED)
MW-4
G-2
L-2
MW-2
LANDFILL LICENSE NO. 203
G-1
R-1
MW-1
MW-3
G-3
A'
LEGEND
MW-1 ▲ MONITORING WELL LOCATIONS
G-1 ■ HAND-AUGERED TEST BORING LOCATIONS
R-1 ● DRILLED TEST BORING LOCATIONS
L-1 ○ SURFICIAL SOIL SAMPLE LOCATIONS
NOTE: SECTION A-A', SEE FIGURE 3-2.
GEO RESEARCH

FIGURE 3-1

TEST BORING LOCATIONS
CITY OF LAUREL LANDFILL
LAUREL, MONTANA



NOTES:

1. FINAL COVER THICKNESS IS A MINIMUM OF TWO FEET.
2. FINAL COVER IS UNDERLAIN BY SOLID WASTE.
3. THE THICKNESSES OF SOLID WASTE, CLAY, AND SHALE UNDER THE FINAL COVER WERE NOT DETERMINED.
4. APPARENT DIP OF BEDDING IN THE SHALE IS NEARLY LEVEL.

SECTION A–A'

HORZ. SCALE: 1" = 200 FT.
VERT. SCALE: 1" = 20 FT.

∇ INDICATES STATIC WATER LEVEL MEASUREMENT

FIGURE 3–2

GEOLOGIC CROSS–SECTION
A – A'
CITY OF LAUREL LANDFILL
LAUREL, MONTANA

3.1.3 Soil Sample Laboratory Testing

Because of the shallow depth to bedrock at the site, few soil samples were collected. Of the samples, one was analyzed for total organic carbon and pH and one was analyzed for moisture content and grain size distribution using sieve and hydrometer methods (ASTM D422 and ASTM D1140). The results of this testing are summarized on Figure 3-3. One sample contained 8 percent sand, 59 percent silt and 33 percent clay. Also shown on Figure 3-2 are grain size distribution curves for soil samples of cover material collected for the landfill closure design. The locations of the sample collection points, L-1 and L-2, are shown on Figure 3-1.

One soil sample from R-1 was analyzed for soil pH and total organic carbon. The pH was 7.8 and the TOC was 0.5%. A moisture content of 16.0 percent was measured on a soil sample from R-1. The laboratory reports are presented in Appendix E.

3.1.4 Hydraulic Conductivity Measurements in the Vadose Zone

Measurements of hydraulic conductivity in the vadose zone were attempted at four locations during the additional investigation. A Guelph Permeameter (GP) was installed at three locations, G-1, G-2, and G-3. The GP provides a measure of field-saturated hydraulic conductivity (K_{fs}) which is considered appropriate when modelling in the vadose zone (Reynolds and Elrick, 1986). This method is a measure of total hydraulic conductivity, but the dimensions of the test sections indicate that the conductivity in the horizontal direction are dominant. Since all of these test were conducted in initially unsaturated soils, entrapped air may be present in the pores which impedes the flow of ground water. The field-saturated hydraulic conductivity values measured in typical unsaturated soils may be less than fully saturated hydraulic conductivity by a factor of two (Stephens et al., 1987). The matric flux potential is a measurement of capillarity and is dependent on the degree of saturation. The matric flux potential is zero at full saturation (Reynolds and Elrick, 1987).

Guelph Permeameter Readings

A Guelph Permeameter (GP) was installed in test boring G-1 at a depth of 20 inches. Apparent steady rates of infiltration were obtained at two head levels. However, the drop in water levels was due to leakage through the vacuum seals rather than through the pipette. The GP was installed in test boring G-2 at a depth of 31 inches and two apparent steady infiltration rates were recorded. The GP was then installed in test boring G-3 at a depth of 32 inches. The failure of the vacuum seal may have been due to the low temperatures experienced during field activities and all infiltration rates recorded are overestimates of true infiltration rates due to leakage. Calculations were conducted in accordance with the standardized procedure for the GP according to the manufacturers instructions (Soilmoisture Corp., 1986). The results are summarized in Table 3-1. The calculations are not presented herein due to the lack of confidence in the data.

3.1.3 Soil Sample Laboratory Testing

Because of the shallow depth to bedrock at the site, few soil samples were collected. Of the samples, one was analyzed for total organic carbon and pH and one was analyzed for moisture content and grain size distribution using sieve and hydrometer methods (ASTM D422 and ASTM D2216). The results of this testing are summarized on Figure 3-2. One sample contained 8 percent sand, 50 percent silt and 42 percent clay. Also shown on Figure 3-2 are grain size distribution curves for soil samples of cover material collected for the landfill cover design. The locations of the sample collection points, L-1 and L-2, are shown on Figure 3-1.

One soil sample from R-4 was analyzed for soil pH and total organic carbon. The pH was 7.8 and the TOC was 0.5%. A moisture content of 16.0 percent was measured on a soil sample from R-1. The laboratory reports are presented in Appendix E.

3.1.4 Hydraulic Conductivity Measurements in the Vadose Zone

Measurements of hydraulic conductivity in the vadose zone were attempted at three locations during the geotechnical investigation. A Guelph Permeameter (GP) was installed at three locations, G-1, G-2, and G-3. The GP provides a measure of field-saturated hydraulic conductivity (K_{fs}) which is considered appropriate when looking in the vadose zone (Reynolds and Elrick, 1986). The method is a measure of local hydraulic conductivity, but the dimensions of the test sections indicate that the conductivity in the horizontal direction are dominant. Since all of these test were conducted in unsaturated materials, entrapped air may be present in the pores which impedes the flow of ground water. The field-saturated hydraulic conductivity values measured in typical unsaturated soils may be less than fully saturated hydraulic conductivity by a factor of two (Reynolds et al., 1983). The matric flux potential is a measurement of capillarity and is dependent on the degree of saturation. The matric flux potential is zero at full saturation (Reynolds and Elrick, 1987).

Guelph Permeameter Results

A Guelph Permeameter (GP) was installed in test boring G-1 to a depth of 30 inches. Apparently steady rates of infiltration were obtained at two head levels. However, the drop in water levels was due to leakage through the attachment seals rather than through the pipette. The GP was installed in test boring G-2 at a depth of 31 inches and two apparent steady infiltration rates were recorded. The GP was then installed in test boring G-3 at a depth of 32 inches. The failure of the vacuum seal may have been due to the low temperatures experienced during field activities and infiltration rates represent overestimates of true infiltration rates due to leakage. Calculations were conducted in accordance with the standardized procedures for the GP according to the manufacturer's instructions (Soilmoisture Corp., 1986). The results are summarized in Table 3-1. The calculations are not presented herein due to the lack of confidence in the data.

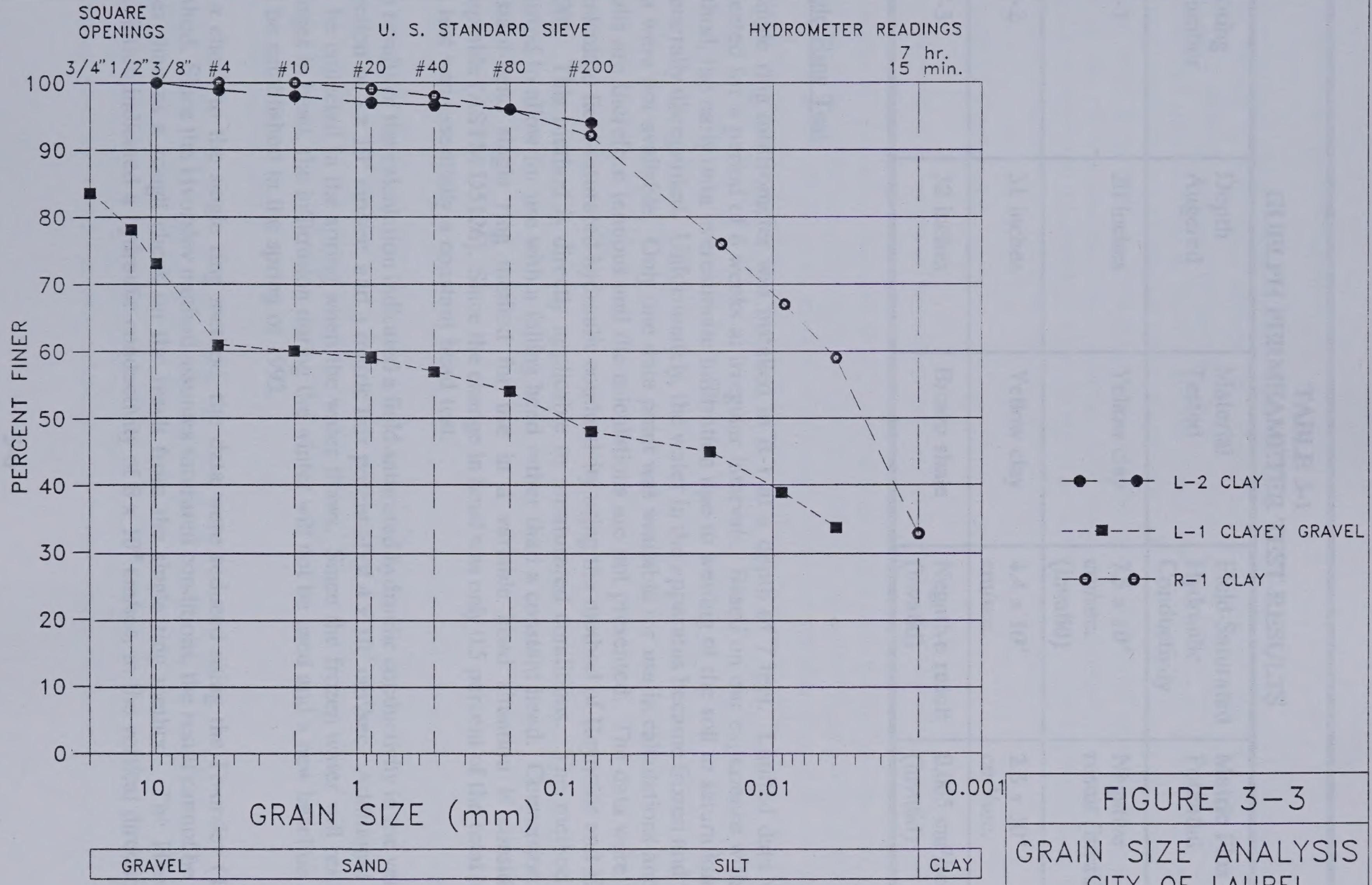


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FIGURE 3-3

GRAIN SIZE ANALYSIS
CITY OF LAUREL
LANDFILL
LAUREL, MONTANA

TABLE 3-1
GUELPH PERMEAMETER TEST RESULTS

Boring Number	Depth Augered	Material Tested	Field-Saturated Hydraulic Conductivity	Matric Flux Potential
G-1	20 inches	Yellow clay	7.5 x 10^{-5} cm/sec. (invalid)	Negative result (invalid)
G-2	31 inches	Yellow clay	4.4 x 10^{-4} cm/sec.	2.3 x 10^{-3} cm^2/sec.
G-3	32 inches	Brown shale	Negative result (invalid)	0.065 cm^2/sec. (invalid)

Single Ring Test

A single ring infiltrometer was installed in R-1 at a depth of 7 feet. Limited data were collected for a period of 6 weeks at irregular intervals. Based on our experience with this method, the early data overestimate infiltration due to wetting of the soil to saturation and is generally disregarded. Unfortunately, the water in the apparatus became frozen and later data were not available. Only one data point was available for use in calculations and the results are therefore tenuous and the calculations are not presented. The data were used to calculate field-saturated hydraulic conductivity using the method of Reynolds and Elrick (1990). This method is directly applicable to unsaturated conditions. The method was adjusted to allow for use with a falling head rather than a constant head. Conversion of a constant-head single ring method for use in a variable head situation is considered acceptable (ASTM D5126). Since the change in head was only 0.5 percent of the total head, this test was essentially a constant head test.

The results of the calculation indicated a field-saturated hydraulic conductivity in the vertical direction of 8 x 10^{-8} cm/sec. and a matric flux potential of 4 x 10^{-7} cm^2/sec. Additional data will be collected in the spring when the water thaws. Since the frozen water will result in changes in head, the infiltration during the winter will not be used and a new baseline level will be established in the spring of 1993.

As a check to the single ring method, the data were reduced using the Hvorslev (1951) method. Since the Hvorslev method assumes saturated conditions, the result cannot be used other than as a rough check on the result from the single ring method. The Hvorslev calculation indicated a hydraulic conductivity of 8 x 10^{-8} cm/sec. in the vertical direction.

3.2 Ground-Water Investigation

Shallow ground water was encountered within shale in all test borings which penetrated the shale. Water entered these borings very slowly and a discharge could not be estimated. MW-1 and MW-2 encountered ground water in dark brown shale while MW-3 and MW-4 encountered ground water in black shale just below a bed of hard gray shale. The depth at which ground water was encountered ranges from 17 to 35 feet. The static water levels ranged from 5 to 27 feet. MW-1 displays approximately 11 feet of head and the water-bearing zone is considered to be confined. MW-3 displays approximately 13 feet of head and is also considered confined. Ground water in the other two wells displayed little to no head and these water-bearing zones are considered to be unconfined.

3.2.1 Well Completion

Ground water monitoring wells were completed in four of the test borings (MW-1 through MW-4). Monitoring well construction consisted of two-inch diameter, flush-threaded, Schedule 40, polyvinyl chloride (PVC) casing with 0.020-inch slotted screen and blank sections. The wells were screened for five feet with the saturated zone falling within the screened interval. 10/20 mesh silica sand was used to fill the annulus around the screens to a depth of approximately one foot above the top of the screen. Bentonite chips were placed above the sand. In wells MW-1 and MW-2, the chips were placed to a depth of three feet from the surface. In wells MW-3 and MW-4, grout consisting of Portland cement with 3 percent added bentonite was tremied into the wells above the chips to a depth of three feet. Six-inch diameter steel well protectors with locking caps were set to a depth of three feet and concrete seals and pads were poured around the protectors. PVC caps were placed on the tops of the well casings.

Details of well completion are presented on the GeoResearch well completion logs in Appendix C and on the Department of Health and Environmental Sciences (DHES) well completion logs in Appendix D.

Following well construction, the wells were surveyed for relative elevation by the City of Laurel. The elevations were based on an approximate elevation at the northwest corner of section 33 as reported on the U.S. Geological Survey (USGS) topographic quadrangle map. Elevations are suitable for on-site use, but are not accurately correlated to a USGS datum. These elevations and calculated well construction elevations are presented in Appendix D.

3.2.2 Well Development

Following completion, the wells were developed using a bailer for surging and water removal. The water level in MW-1 could be bailed down to a depth of approximately ten feet and development resulted in a reduction of suspended sediment in the bailed water. The other wells could easily be bailed dry and development was relatively unsuccessful at reducing the amount of suspended material in the bailed water. Because wells MW-2, MW-

3 and MW-4 yield less than one gpm, they are considered to be completed in water-bearing zones (WBZ's) rather than aquifers. Well development forms are presented in Appendix D on the reverse sides of the monitoring well completion logs.

3.2.3 Direction of Ground-Water Flow

Static water levels were obtained for four wells in the shallow bedrock water-bearing zones. It should be noted that it is possible that the water-bearing zones encountered are not continuous and may not represent a single zone. The elevations of the water-bearing zones are similar for wells MW-1 and MW-3 both of which are completed in a confined WBZ. This WBZ may be continuous between these two wells. However, the unconfined zones encountered in MW-2 and MW-4 do not have similar elevations and probably represent different water-bearing zones than the confined WBZ.

Based on these water levels, the approximate direction of ground water flow appears to be toward the southeast in the vicinity of wells MW-1, MW-2, and MW-3 if the WBZs were connected. Since the wells are probably not interconnected, gradient data are not considered to be reliable. Static water elevations and a possible contour configuration of equal water level elevation for the uppermost water-bearing zone are presented on Figure 3-4. Based on these contours, a possible gradient is approximately 0.012 feet per foot.

3.2.4 Aquifer Testing

Aquifer tests were performed in all four completed wells. The tests were conducted after the wells were developed and sampled. The tests were conducted using a pressure transducer installed at the bottom of each well which was connected to a datalogger which recorded water levels in the wells at selected intervals during testing. MW-1 and MW-3 display sufficient hydraulic head to be considered confined and MW-2 and MW-4 displayed little head and are considered unconfined.

In the confined wells, a solid slug was introduced into the well and the water levels were recorded as the well returned to static conditions. In MW-1, the slug was removed and levels were recorded as they recovered to static conditions resulting in two data sets for that well, "slug-in" and "slug-out".

In the unconfined wells, the slug was introduced into the wells, but data were not collected during recovery. After the wells returned to static conditions, the slug was removed and the "slug out" water levels were recorded as the wells recovered.

In addition to the tests completed using the data logger, a slug test was completed in MW-2 using the solid slug and a well probe and clock to collect the data.

The water-bearing zone encountered in each well was located in fractured shale bedrock. Based on exposures of the shale in a cut slope on the container site near MW-4, the

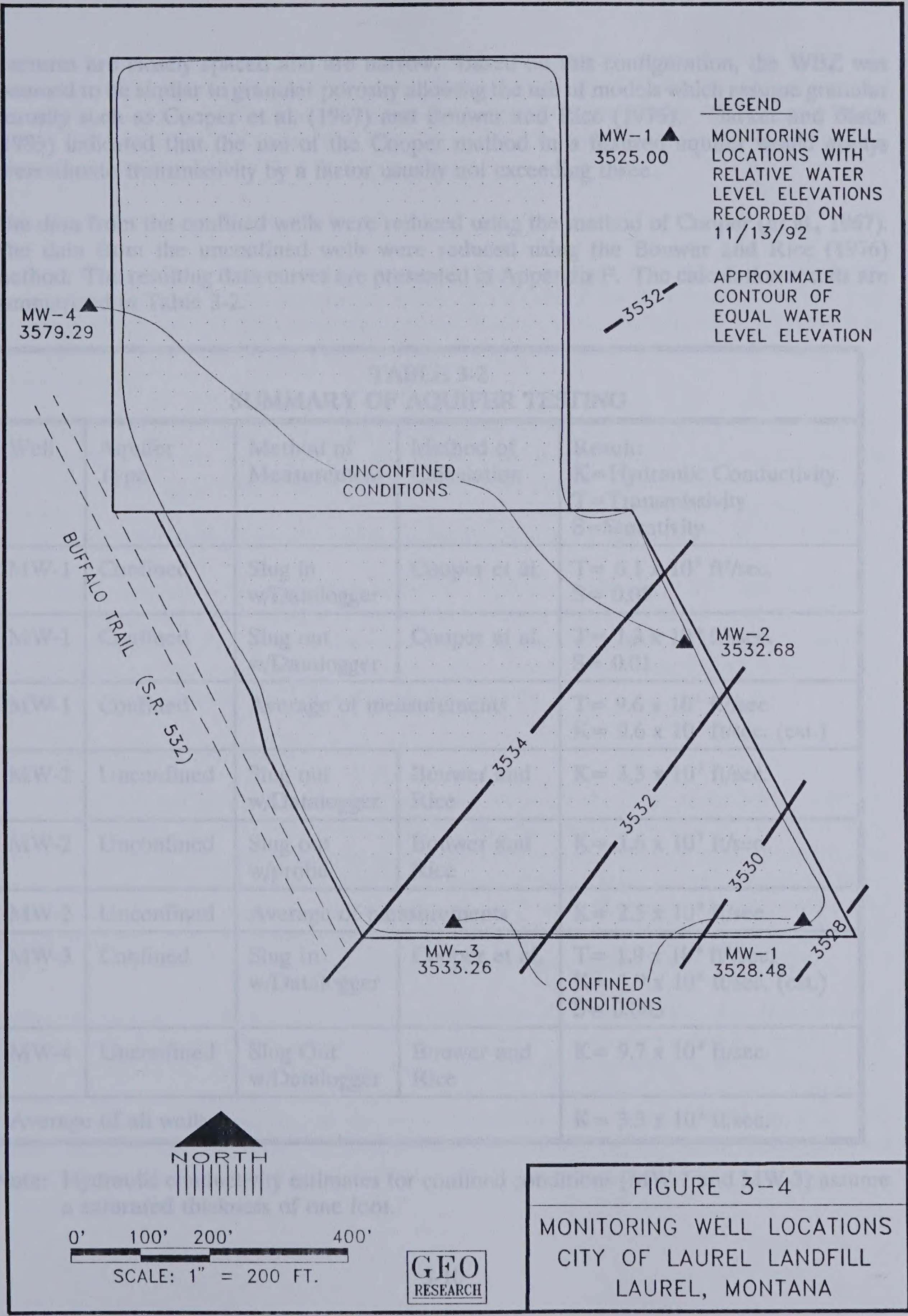

FIGURE 3-4

MONITORING WELL LOCATIONS
CITY OF LAUREL LANDFILL
LAUREL, MONTANA

fractures are closely spaced and are narrow. Based on this configuration, the WBZ was assumed to be similar to granular porosity allowing the use of models which assume granular porosity such as Cooper et al. (1967) and Bouwer and Rice (1976). Barker and Black (1983) indicated that the use of the Cooper method in a fissured aquifer would always overestimate transmissivity by a factor usually not exceeding three.

The data from the confined wells were reduced using the method of Cooper (et al., 1967). The data from the unconfined wells were reduced using the Bouwer and Rice (1976) method. The resulting data curves are presented in Appendix F. The calculation results are summarized in Table 3-2.

TABLE 3-2
SUMMARY OF AQUIFER TESTING

Well	Aquifer Type	Method of Measurement	Method of Calculation	Result: K=Hydraulic Conductivity T=Transmissivity S=Storativity
MW-1	Confined	Slug in w/Datalogger	Cooper et al.	T= 6.1×10^{-5} ft^2/sec. S= 0.05
MW-1	Confined	Slug out w/Datalogger	Cooper et al.	T= 1.3×10^{-4} ft^2/sec. S= 0.01
MW-1	Confined	Average of measurements		T= 9.6×10^{-5} ft^2/sec. K= 9.6×10^{-5} ft/sec. (est.)
MW-2	Unconfined	Slug out w/Datalogger	Bouwer and Rice	K= 3.3×10^{-5} ft/sec.
MW-2	Unconfined	Slug out w/probe	Bouwer and Rice	K= 1.6×10^{-5} ft/sec.
MW-2	Unconfined	Average of measurements		K= 2.5×10^{-5} ft/sec.
MW-3	Confined	Slug In w/Datalogger	Cooper et al.	T= 1.9×10^{-6} ft^2/sec. K= 1.9×10^{-6} ft/sec. (est.) S= 0.003
MW-4	Unconfined	Slug Out w/Datalogger	Bouwer and Rice	K= 9.7×10^{-6} ft/sec.
Average of all wells				K= 3.3×10^{-5} ft/sec.

Note: Hydraulic conductivity estimates for confined conditions (MW-1 and MW-3) assume a saturated thickness of one foot.

Based on the hydraulic conductivity and transmissivity measurements presented in Table 3-2, an average site hydraulic conductivity is on the order of 3.3 x 10^{-5} ft/sec. The storativity measurements in the confined wells are relatively high for a confined aquifer, especially at MW-1. This may indicate that the WBZ may be connected to a nearby area having unconfined conditions.

3.2.5 Rate of Ground-Water Movement

The average hydraulic conductivity presented in Table 3-2 can be used for modeling the overall site conditions in the uppermost WBZ. Since two of the wells are unconfined and two are confined, the gradient data are tenuous. Based on the available data, a gradient of 0.012 feet per foot is assumed. For the purposes of calculation, a porosity of ten percent is also assumed.

Using Darcy's Law, a tracer velocity for ground water at the site is estimated to be 4.0 x 10^{-6} ft./sec. or 0.34 feet per day. This rate cannot be directly applied to estimating travel time to the nearest receptor wells because the receptor wells are completed in a different aquifer. Because the nearest receptors are at a distance of approximately one mile, it can be inferred that ground water exiting the site could conceivably travel that distance in 40 to 50 years.

The landfill trenches were most likely excavated into the shale at the site and thus travel through the clay soil is not considered in modeling. Since the depth to the uppermost WBZ is relatively shallow in two of the wells and unsaturated hydraulic conductivity measurements was not taken for the shale were invalid, the rate of travel for leachate from the base of the landfill to the uppermost WBZ is not estimated herein.

3.2.6 Ground-Water Sampling

Samples of ground water were collected from each of the four monitoring wells on November 13 and 14, 1992. Prior to sampling, the static water levels were recorded from each well. At each well, the volume of water contained within the well casing was calculated based on these levels and three well casing volumes of water were purged using a stainless steel bailer. Prior to purging and sampling at each well, the stainless steel bailer was decontaminated using a Liquinox and deionized (DI) water wash with a triple DI water rinse. New polypropylene rope and vinyl gloves were used at each well.

Following purging, the wells were sampled using the stainless steel bailer. The sample water was decanted into laboratory-provided 40 mL glass vials. Laboratory provided hydrochloric acid was added to the vials and the vials were capped and stored inverted in a cooler on ice. These samples were collected for Volatile Organic Compound (VOC) analysis. Additional sample water was then collected using the stainless steel bailer and decanted into a 500 mL plastic bottle which was preserved with laboratory-provided sulfuric acid. These samples were collected for chemical oxygen demand (COD) and nitrogen analysis.

The wells were then sampled using a PVC bailer which was decontaminated prior to sampling using a ten percent nitric acid and DI water solution followed by a triple rinse of DI water. Sample water was decanted into a glass filtration unit which was also decontaminated with nitric acid and DI water. The water was filtered under a vacuum through a filter plate with a pore size of 0.45 μm. The filtered water was transferred into plastic sample bottles and preserved with laboratory-provided nitric acid. These samples were collected for dissolved metals analysis. Additional sample water was collected into plastic bottles using the PVC bailer for major minerals and properties analysis. No chemical preservatives were used in these samples.

All sample bottles were labeled and stored on ice in a cooler and were delivered directly to Energy Laboratories in Billings under chain of custody. Samples were labeled as "MW-1", MW-2", etc. according to the well from which they were collected. Quality Assurance/Quality Control (QA/QC) samples included a duplicate sample collected from MW-1 which was labeled "MW-5" and a blank sample which was labeled "MW-6". The blank was collected by passing DI water through the decontaminated field equipment into sample jars and preserved the same as the ground-water samples.

Following collection of laboratory samples, additional sample water was collected for field analysis.

3.2.7 Ground-Water Sample Analyses

Field Analysis

The ground-water samples were analyzed in the field for pH, temperature, and specific conductance. The results are presented in Table 3-3 along with the corresponding laboratory analytical results.

TABLE 3-3
GROUND WATER FIELD ANALYTICAL RESULTS

Well	pH (s.u.)	Laboratory pH (s.u.)	Temperature (°C)	Specific Conductance (μmhos/cm)	Laboratory Specific Conductance
MW-1	6.60	6.8*	12.2	25476	27000*
MW-2	6.72	7.0	12.3	18612	18800
MW-3	7.17	7.4	11.8	29568	33800
MW-4	6.87	7.2	12.1	8184	8210
Blank	7.96	5.8	11.8	5.28	7

* Average of three analyses

The differences between field and laboratory reported values for pH and specific conductance are reasonable with the exception of the pH of the blank sample. This may be due to lowered equipment precision at the very low concentrations of H^+ ions in the deionized water. The reasonable agreement indicates that sample integrity was maintained during sample delivery.

Laboratory Analysis

The ground water samples were analyzed for the suite of inorganic and organic parameters contained in §16.14.706 ARM plus total alkalinity as calcium carbonate and tetrachloroethene (PCE). The laboratory reports are presented in Appendix G. Summaries of selected organic parameters are presented in Table 3-4 and summaries of selected inorganic parameters are presented in Table 3-5. In addition to analysis of the samples as specified, laboratory duplicate analyses for all non-VOC parameters were completed for the sample labeled "MW-1" and spiked analyses were completed for selected non-VOC parameters for "MW-2" and selected VOC parameters for all samples.

TABLE 3-4
SELECTED ORGANIC ANALYTICAL PARAMETERS

Constituent (μg/l)	Downgradient Wells			Upgradient Well	Equipment Blank
	MW-1	MW-2	MW-3	MW-4	MW-6
Chloroform	<1.0	<1.0	<1.0	<1.0	1.7
Dichlorodifluoromethane	<1.0	4.3	<1.0	<1.0	<1.0
Methylene chloride	<1.0	2.0	<1.0	<1.0	4.1

Note: Other parameters evaluated, but not detected. See laboratory reports in Appendix G.

Few organic analytical parameters were detected at the site and interpretation of the results requires a discussion of the QA/QC samples. The equipment blank (labeled MW-6) included two detectable constituents: chloroform and methylene chloride. An equipment blank sample collected for a different project a week following sample collection at the Laurel landfill using the same equipment and water source also contained detectable concentrations of chloroform and methylene chloride plus bromodichloromethane. This repeatability confirms that the source of these constituents is not at the Laurel landfill. A likely source is leaching from the polypropylene carboy used to store and transport the deionized water.

The only VOCs detected in actual ground water samples were dichloroflouromethane and methylene chloride in MW-2. The presence of methylene chloride is suspect due to the detection in the equipment blank. No maximum concentration level (MCL) exists for

dichlorodiflouromethane (commonly referred to as a CFC) which is used as a refrigerant and aerosol propellant.

Generally, lack of VOCs in the ground water samples indicates that contamination by organic constituents is minimal to not detectable at the site. Based on our experience, key indicators of contamination by MSW leachate are trichloroethene and tetrachloroethene. Both are absent at the site.

Overall, the quality of the ground water at the site is poor. Maximum contaminant levels (MCLs) for drinking water were exceeded at MW-2 for nitrate and cadmium. The MCL for silver was exceeded at MW-3. All of the wells indicated very high concentrations of total dissolved solids (TDS). The water is a sodium sulfate type which is typical of Cretaceous shales in Montana. For many of the analytes evaluated, concentrations were higher at the downgradient wells than at the upgradient well. These increases could be attributable to the presence of leachate or due to a longer residence time within the shale at the downgradient wells. MW-4 may be nearer a recharge zone for the shale WBZ and the ground water would have less contact with the shale and would have less dissolved constituents. If the residence time of the water is short enough, measurement of dissolved oxygen in the ground water may support this case.

Based on published analytical data (Hutchinson, 1983), a domestic well in the northwest quarter of section 4 south of the site had lower concentrations of all constituents common to both analyses, but the relative concentrations were similar. This indicates that the water in this well is a blend of the shale water and other water. The source of the other water could be from the alluvial aquifer which has low concentrations of total dissolved solids or from direct infiltration of meteoric water.

TABLE 3-5
SELECTED INORGANIC ANALYTICAL PARAMETERS

Constituent, (mg/l) unless otherwise noted	Downgradient Wells			Upgradient Well	Equipment Blank
	MW-1[1]	MW-2	MW-3	MW-4	MW-6
Potassium	39	33	28	27	<1
Sodium	4540	2300	10,500	954	<1
Calcium	413	404	364	421	<1
Magnesium	4010	2890	715	850	<1
Sulfate	25,000	16,400	23,900	5530	2
Chloride	191	199	354	96	<1
Carbonate	0	0	0	0	0
Bicarbonate	1060	602	1460	711	2
Total Dissolved Solids	38,800	24,400	36,100	8830	6
Total Alkalinity as $CaCO_3$	867	494	1200	583	2
Specific Conductance[2]	27,000	18,800	33,800	8210	7
pH[3]	6.8	7.0	7.4	7.2	5.8
Nitrate as N	<.05	51.5	0.14	1.29	<0.05
Ammonia as N	0.3	<0.1	4.5	0.3	<0.1
Chemical Oxygen Demand	40	53	10	20	2
Total Suspended Solids	940	3430	1900	2820	<1
Total Cyanide	<0.005	<0.005	<0.005	<0.005	<0.005
Arsenic	.015	<0.05	0.005	<0.005	<0.005
Barium	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	<0.01	0.024	<0.01	<0.001	<0.001
Chromium	<0.1	<0.1	<0.1	<0.01	<0.01
Iron	<0.3	<0.3	1.11	<0.3	<0.03
Lead	<0.1	<0.1	<0.1	<0.1	<0.01
Manganese	11.0	0.13	0.32	1.00	<0.02
Mercury	<0.005	<0.005	<0.005	<0.005	<0.001
Selenium	<0.005	0.89	<0.005	0.18	<0.005
Silver	<0.06	<0.06	0.404	<0.005	<0.005

[1] Average of three analyses

[2] μmhos/cm

[3] s.u.

4.0 CONCLUSIONS

Based on the additional investigation and findings described in previous chapters, the following conclusions can be made:

1. Prior to landfilling, the surficial geological unit at the site was a yellowish brown clay which displays relatively low hydraulic conductivity. It is likely that this soil was excavated and used as cover material.
2. The soil is underlain by black shale probably belonging to the Niobrara formation. Minor occurrences of gravel were noted off the site to the north and east.
3. The uppermost ground water at the site is present in the black shale. Two wells were completed in unconfined water-bearing zones and two wells were completed in confined water-bearing zones. It was not determined if any of the zones encountered are interconnected. Of the four wells, only one (MW-1) was capable of producing one gallon per minute, the regulatory definition of an aquifer.
4. The approximate direction of ground water flow is toward the southeast. Potential receptors are present at a distance of one mile. The receptor wells are completed in a gravel aquifer which may be partially recharged by the shale water-bearing zones and other sources. The tracer velocity in the shale is approximately 0.34 feet per day.
5. The overall quality of ground water at the site is poor which is typical of Cretaceous shales in Montana. Significant increases in several inorganic chemical parameters were detected from the background well to the three downgradient wells. This suggests that leachate may be entering the ground water at the site. However, these increases may also be attributable to increased contact time with the shale. Three MCLs were exceeded, nitrate and cadmium at MW-2 and silver at MW-3.
6. The ground water has not been significantly impacted by organic chemical parameters which suggests that either leachate has not impacted ground water or that any organic leachate which may have impacted the ground water has attenuated to concentrations below detection. The possible exception is dichlorodifluoromethane, a CFC, which was detected in one well.

5.0 GROUND-WATER MONITORING RECOMMENDATIONS

5.1 Resampling for Organic Parameters

Since VOCs were detected in the equipment blank sample as well as the sample from MW-2, it is unclear whether or not VOC contamination is present. In order to confirm the presence or absence of organic leachate, it is recommended that MW-2 be resampled for VOCs as soon as is practicable. The laboratory should identify and quantify any peaks obtained using the gas chromatograph/mass spectrometer (GC/MS).

5.2 Ground-Water Monitoring

According to § § 16.14.706 and 16.14.707 MCA, a ground water monitoring plan and sampling and analysis plan must be prepared for the facility. The details of a ground-water monitoring plan are not presented in this report. This plan is being prepared under separate cover. Included in the plan will be a Sampling and Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), Health and Safety Plan (HSP) and a well maintenance plan. Generally, the plan includes a biannual sampling frequency to be conducted in April and October and a parameter list the same as that included in this report with possible additional parameters based on the findings of resampling of MW-2.

5.3 Abandonment of R-1

Test boring R-1 was completed as a shallow hydraulic conductivity test boring including steel casing driven with a bentonite seal. This boring did not encounter solid waste or ground water and thus will have little effect on the site. Additional data should be collected during 1993 after freezing weather has ended. Following collection of sufficient data for calculations, this boring can be abandoned at any time by removing the casing with a backhoe and backfilling the hole with bentonite or on-site clay. The backfill should be compacted and mounded above grade to minimize infiltration.

6.0 LIMITATIONS

The conclusions and recommendations in this report are based on:

- 4 test borings to ground water;
- 1 test borings for permeability testing;
- 3 hand-augered borings for permeability testing;
- 6 laboratory soil tests;
- 6 aquifer tests;
- 4 unsaturated permeability tests;
- 6 laboratory analyses of water samples; and the
- Observations of our Project Hydrogeologist.

It is possible that variations in soil and bedrock conditions between borings and test pits could exist between or beyond the points of exploration or the ground-water conditions may change, both of which may require additional studies, consultation, and possible revisions.

This report was prepared with the generally accepted standard of practice for hydrogeology which existed in Montana for similar projects a the time the report was written. No other warranty, expressed or implied, is made.

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APPENDIX A

LOGS OF NEARBY WATER WELLS

111 02S 24E 04BCD

Yellowstone

FORM No. 603 New 7-7

RECEIVED

NOV 22 1974

of 21 Beartooth Sub. D.

File No. 3902-943Q

2S-24E-4

STATE OF MONTANA

Department of Natural Resources and Conservation

WHITE — DEPARTMENT
PINK — BUREAU
CANA
GOLD

017988

WELL LOG REPORT

State law requires that this form be filed by the water well driller on any water well completed by him on and after July 1, 1973 within sixty (60) days after completion of the well.

1. WELL OWNER: Name Larry T. Riede Address 320½ Durland Dr. Laurel, Mt

2. WELL LOCATION: County Yellowstone ; SE¼SW¼NW¼, Sec. 4 , Twp. 2 N-[✓ S] Rg. 24 [✓ E]-W

3. PROPOSED USE: [✓ Domestic] ___ Stock ___ Municipal ___ Industrial ___ Lawn and Garden ___ Irrigation ___ Other (*if other, specify*)

4. METHOD DRILLED: ___ Cable ___ Bored [✓ Forward Rotary] ___ Reverse Rotary ___ Jetted ___ Other (*if other, specify*)

5. WELL CONSTRUCTION:

Diameter of hole 8 inches. Depth 110 ft.

Casing: [✓ Steel] ___ Plastic ___ Concrete

___ Threaded [✓ Welded] ___ Other (*if other, specify*)

Pipe Weight: Dia.: From: To:

20 lb/ft. 7 inches 1+ feet 110 feet

___ lb/ft. ___ inches ___ feet ___ feet

___ lb/ft. ___ inches ___ feet ___ feet

Was perforated pipe used? [✓ Yes] ___ No

Length of pipe perforated 22 feet

Was casing left open end? [✓ Yes] ___ No

Was a well screen installed? ___ Yes ___ No

Material ___ Dia. ___ inches

(*stainless steel, bronze, etc.*)

Perforation type: [✓ slots] ___ holes

Size 1/8 set from 88 feet to 110 feet

Size / set from ___ feet to ___ feet

Size ___ set from ___ feet to ___ feet

Was a packer or seal used? [✓ Yes] ___ No

If so, what material Butyl

Well type: ___ Straight screen [✓ Graveled]

Was the well grouted? [✓ Yes] ___ No

To what depth? 8 feet

Material used in grouting Cement

Well head completion: Pitless adapter ___

12" above grade ✓ Other ___

(*If other, specify*) ___

Was the well disinfected? ___ Yes [✓ No]

6. WATER LEVEL:

Static water level 90 ft. below land surface

If flowing: closed-in pressure ___ psi

GPM flow ___ through ___ inch pipe

Controlled by: ___ Valve ___ Reducers

___ Other, specify ___

7. WELL TEST DATA: ___ Pump [✓ Bailer] ___ Other

(*If other, specify*) ___

Pumping level below land surface:

95 ft. after 2 hrs. pumping 15 gpm

___ ft. after ___ hrs. pumping ___ gpm

8. WELL LOG:

Depth (ft.) From	Depth (ft.) To	Formation
0	40	Sandy Top Soil
40	90	Sand
90	105	Gravel
105	110	Blue Shale

(*Use separate sheet if necessary*)

9. DATE STARTED: 6/29/74

10. DATE COMPLETED: 8-19-74

11. WAS WELL PLUGGED OR ABANDONED? ___ Yes [✓ No]

If so, how /

12. DRILLER'S CERTIFICATION:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Digger Drilling 197

Driller's or Firm Name *License No.*

3143 Prairie Dr. Billings, Mt. 59101

Address

8-21-74

Signed by *Date*

02S 24E 04

M+

Form No. 603 R9/82 Yellowstone

File No. ____________

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion 016125

1. WELL OWNER
Name Bob Auer

2. CURRENT MAILING ADDRESS
2927 Beech Ave
Billings, Montana

3. WELL LOCATION
County Yellowstone
Township 2S N/S Range 24E E/W
NW¼ ¼ ____ ¼ ____ ¼ Section 4
Lot 5 Block 1-2-3 Amend
Subdivision Groshell Sub

4. PROPOSED USE Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify ____

5. DRILLING METHOD ____ cable, ____ bored, X forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify) ____

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations and/or Screen: Kind Size	From (feet)	To (feet)
7 7/8"	6 5/8" steel .250	0'	27'	Surface Pipe		
6"	5" OD PVC 160#	27'	112'	1/8 slot	106'	112'

Was casing left open end? X Yes ____ No
Was a packer or seal used? X Yes ____ No
If so, what material Bentonite
Was the well gravel packed? ____ Yes X No
Was the well grouted? X Yes ____ No
To what depth? 27'
Material used in grouting Bentonite
Well head completion: Pitless adapter ____ Yes ____ No
Top of casing 12 in. or greater above grade X Yes ____ No

7. WHAT IS THE TEMPERATURE OF THE WATER?
____ Degrees Fahrenheit ☐ Measured ☐ Estimated

8. WATER LEVEL
Static water level 82' feet below land surface
If flowing; closed-in pressure ____ psi
____ gpm
Controlled by: ____ valve, ____ reducers, ____ other, (specify) ____

9. WELL TEST DATA X pump ____ bailer ____ other, (specify) ____
Pumping level below land surface:
108 ft. after 2 hrs. pumping 12' gpm
____ ft. after ____ hrs. pumping ____ gpm

10. WAS WELL PLUGGED OR ABANDONED? ____ Yes X No
If yes, how? ____

11. DATE COMPLETED 9-15-83

12. WELL LOG

Depth (ft.) From	To	Formation
0'	27'	Brown clay-gravel
27'	101'	Brown sticky clay
101'	112'	gravel sand

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
Date 9-26-83
Firm Name Billings Drilling
Address 14023 Roundup Rd, Blgs
Signature LaVern Jewett License No. 264#

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION **DNRC**
32 SOUTH EWING HELENA, MONTANA 59620 449-3962

DEPARTMENT — BUREAU COPY

III

YELLOWSTONE

Form No. 603 R9/82

File No. ______

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after comple

1016126

1. **WELL OWNER**
Name Bernard Coisen

2. **CURRENT MAILING ADDRESS**
11st + word Aye
Red Lodge MT 59068

3. **WELL LOCATION**
County Yellowstone
Township 2 N/[✓ S] Range 24 [✓ E]/W
¼ ¼ NW ¼ Section 4
Tract 1 Block
Subdivision Beartooth sub.

4. **PROPOSED USE** Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify

5. **DRILLING METHOD** X cable, ___ bored,
___ forward rotary, ___ reverse rotary, ___ jetted,
___ other (specify)

6. **WELL CONSTRUCTION AND COMPLETION**

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations None and/or Screen None Kind Size	From (feet)	To (feet)
6	6"-17#	0	41½			

Was casing left open end? X Yes ___ No
Was a packer or seal used? ___ Yes X No
If so, what material
Was the well gravel packed? ___ Yes X No
Was the well grouted? ___ Yes X No
To what depth?
Material used in grouting
Well head completion: Pitless adapter ___ Yes ___ No
Top of casing 12 in. or greater above grade X Yes ___ No

7. **WHAT IS THE TEMPERATURE OF THE WATER?**
50 Degrees Fahrenheit
☐ Measured ☒ Estimated

8. **WATER LEVEL**
Static water level 22' feet below land surface
If flowing; closed-in pressure ______ psi
______ gpm
Controlled by: ___ valve, ___ reducers,
___ other, (specify)

9. **WELL TEST DATA** ___ pump X bailer
___ other, (specify)
Pumping level below land surface:
26 ft. after 12 hrs. pumping 25 gpm
___ ft. after ___ hrs. pumping ___ gpm

10. **WAS WELL PLUGGED OR ABANDONED?** ___ Yes X No
If yes, how?

11. **DATE COMPLETED** 11-15-83

12. **WELL LOG**

Depth (ft.)

From	To	Formation
0	1	Top Soil + Rock
1	6	Sand Gravel + Clay
6	23	Sandy Clay
23	33	Clay
33	35	Sandy Clay
35	38	Sand
38	41½	Sand + Gravel

RECEIVED
MAR - 5 1984
DEPT. OF NATURAL RESOURCES AND CONSERVATION
BILLINGS OFFICE

(use separate sheet if necessary)

13. **DRILLER'S CERTIFICATION**
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

11-19-83
Date

KAL Well Service
Firm Name

2096th Ave, Laurel MT 59044
Address

Kenneth M. Bever 435
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION **DNRC**

32 SOUTH EWING HELENA, MONTANA 59620 449-3962

DEPARTMENT — BUREAU COPY

111 02S 24E 04 B YELLOWSTONE

rm No. 603 (Rev. 3/75)

File No. 16903-943C

STATE OF MONTANA
Department of Natural Resources and Conservation

White-Department
Pink-Bureau
Yellow-Well owner
Gold-Driller

WELL LOG REPORT

Coded

017984

State law requires that this form be filed by the water well driller withi completion of the well, and Form 602, Notice of Completion of Groundwater filed by the well owner within 60 days after the water has been put to beneficial use.

WELL OWNER Name Rudy Groshelle ~~Leonard [illegible] Lamb~~ Current address LAUREL MONTANA

WELL LOCATION Lot 3, Block 31-2-3 Amended Subdivision Groshelle Heights
County YELLOWSTONE, or NW ¼ ____ ¼ ____ ¼ Sec. 4, T. 2 S, R. 24 E

PROPOSED USE X domestic (includes lawn and garden); ____ stock; ____ municipal; ____ industrial; ____ irrigation; ____ other (specify) ____

METHOD DRILLED ____ cable, ____ bored, X forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify) ____

WELL CONSTRUCTION
Diameter of hole 7 7/8" in.; depth 102' ft.
Casing: ____ steel, ____ plastic, X concrete, ____ threaded, ____ welded, ____ other (specify)
Pipe weight: Plastic
Dia. 5" From 0 To 102'
____ lb/ft ____ in. ____ ft. ____ ft.
____ lb/ft ____ in. ____ ft. ____ ft.
Was casing left open end? X Yes ____ No
Was a well screen installed? ____ Yes X No
Material ____, dia. ____ in. (stainless steel, bronze, etc.)
Was perforated pipe used? X Yes ____ No
Perforation type: X slots ____ holes
Size 1/8" set from 98 ft. to 102 ft.
Size ____ set from ____ ft. to ____ ft.
Was a packer or seal used? X Yes ____ No
If so, what material Rubber & Cement
Well type: ____ Straight screen ____ Graveled
Was the well grouted: ____ Yes X No
To what depth: — ft.
Material used in grouting —
Well head completion: Pitless adapter X
12 in. above grade X, other ____
(if other, specify) ____
Was well disinfected? X Yes ____ No

6. WATER LEVEL
Static water level 30 ft. below land surface
If flowing: closed-in pressure ____ psi
gpm flow ____ through ____ inch pipe
Controlled by: ____ valve ____ reducers ____ other (specify) ____

7. WELL TEST DATA ____ Pump X Bailer ____ Other
(if other, specify) ____
Pumping level below land surface:
30 ft. after 1 hrs. pumping 15 gpm
____ ft. after ____ hrs. pumping ____ gpm

8. WELL LOG

Depth (ft) From	To	Formation
0	10'	SOIL
10	25'	MIXED GRAVEL. DIRT & YELLOW CLAY
25	70'	CLAY & SHALE LAMINATED
70	98'	GRAVEL & Boulders
98	102'	POR GRAVEL & SAND

(use separate sheet if necessary)

9. DATE STARTED July 15 - 1975
DATE COMPLETED July 16 - 1975

10. WAS WELL PLUGGED OR ABANDONED? ____ Yes X No
If so, how? ____

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Roy R. Peil
Driller's or firm name

170
License No.

Billings Mont.
Address

Roy R. Peil
Signed by

8/15/75
date

File No. 111 02S 24E 04Bc

TRIPLICATE Yellowstone

RECEIVED
NOV 15 1968
Montana Bureau of
[illegible]ogy

T2 South R24 East 4

County Yellowstone

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWA[illegible]
OFFICE OF STATE ENGINE[illegible]

017987

Top of Ground
(Elev. above sea level 3385)

Notice of Completion of Groundwater Appropriation by Means of Well

(Under Chapter 237, Montana Session Laws, 1961)

40' Dirt & Gravel

67' Yellow Clay

5' Sand & Gravel
112.5'

Owner Beartooth Enterprises, Inc. Address Box 18, Laurel, Mont.

Driller Beartooth Enterprises, Inc. Address Box 18, Laurel, Mont.

Date of Notice of Appropriation of Groundwater

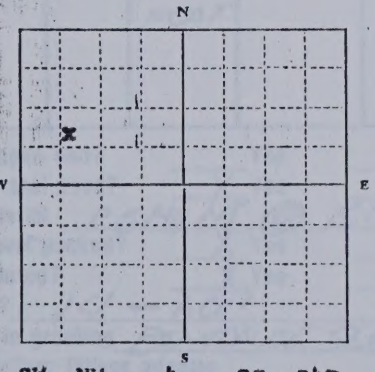
Date well started 9-4-68 Date Completed 10-11-68

Type of well Drilled (dug, driven, bored or drilled) Equipment Used Drill (Churn, drill, rotary or other)

Water Use: Domestic ☒ Municipal ☐ Other ☐ Irrigation ☐ Industrial ☐ Drainage ☐ Stock ☐

☞ Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS		
				Kind Size	From (Feet)	To (Feet)
6"	6" 19 lb. .280	0	112.5	None		



SW ¼ NW Sec. 4 T 2S R 24E

Indicate location of well and place of use, if possible. Each small square represents 10 acres.

Show exact depth of bottom.

Static Water Level for non-flowing Well 20.5 feet.

Shut-in Pressure for Flowing Well

Pumping Water Level 92 feet at 10 gal. per minute.

Discharge in gal. per min. of flowing well

How Tested Bailer Length of Test 1 hour

Remarks: (Gravel packing, cementing, packers, type of shutoff, location of place of use of groundwater if not at well, and any other similar pertinent information, including number of acres irrigated, if used for irrigation) None used.

Robert P. Rosselot
Driller's License Number

Beartooth Enterprises, Inc.
Driller's Signature

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located.

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

Original to the County Clerk and Recorder; duplicate to the State Engineer; Triplicate to the Montana Bureau of Mines and Geology and Quadruplicate for the Appropriator.

Form No. 603 (R 6-84)

File No. 057728

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name FRANK FELKE

2. CURRENT MAILING ADDRESS
4417 HARVEST LANE
BILLINGS, MT 59106

3. WELL LOCATION
County YELLOWSTONE
Township 1 N/[✓ S] Range 24 [✓ E]/W
¼ E½-SE¼ Section 33
Lot Block
Subdivision LAUREL AIRPORT

4. PROPOSED USE Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify

5. DRILLING METHOD ____ cable, ____ bored,
X forward rotary, ____ reverse rotary, ____ jetted,
____ other (specify)

6. WELL CONSTRUCTION AND COMPLETION

Perforations 1/4 INCH and/or Screen

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Kind Size	From (feet)	To (feet)
7 7/8"	6 5/8" 1/4 WALL STEEL	0'	15'			
7 7/8"	6" PVC 160 PSI	15'	98'	1/4" HOLES, 12 PER FOOT	60'	98'

Was casing left open end? ____ Yes X No
Was a packer or seal used? X Yes ____ No
If so, what material CEMENT @ 15'-SURFACE
Was the well gravel packed? X Yes ____ No
Was the well grouted? X Yes ____ No
To what depth? 15' - 60'
Material used in grouting BENTONITE SLURRY
Well head completion: Pitless adapter
X Yes ____ No
Top of casing 12 in. or greater above grade
X Yes ____ No

7. WHAT IS THE TEMPERATURE OF THE WATER?
45° Degrees Fahrenheit
☐ Measured ☒ Estimated

8. WATER LEVEL
Static water level 48' feet below land surface
If flowing; closed-in pressure ____ psi
____ gpm
Controlled by: ____ valve, ____ reducers,
____ other, (specify)

9. WELL TEST DATA ____ pump ____ bailer
____ other, (specify) AIR PUMP
Pumping water level below land surface:
60 ft. after 1 hrs. pumping 40 gpm
60 ft. after 2½ hrs. pumping 40 gpm

10. WAS WELL PLUGGED OR ABANDONED? ____ Yes X No
If yes, how?

11. DATE COMPLETED

12. WELL LOG

Depth (ft.) From	To	Formation
0'	30'	SOIL, SHALE GRAVEL
30'	90'	ALTERNATING SHALE AND GRAVEL, VERY LITTLE SAND

(use separate sheet if necessary)

RECEIVED
SEP 25 1986
DEPT. OF NATURAL RESOURCES
AND CONSERVATION
BILLINGS OFFICE

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
9-1-86
Date
SWEETWATER DRLG & EXPLORATION
Firm Name
BOX 123, BILLINGS, MT 59103
Address
Signature 468
License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59620 444-6610

STATE PUBLISHING CO., HELENA, MONT.

DEPARTMENT - BUREAU COPY

111   1S   24E 34 CB   Yellowstone

Form No. 603 (R 6-84)

File No.______________

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion. 015734

1. WELL OWNER
Name MIKE VISSER

2. CURRENT MAILING ADDRESS
MR MIKE VISSER
RAPELJE, MT 59067

3. WELL LOCATION
County YELLOWSTONE
Township 1 N/[✓ S] Range 24 [✓ E]/W
____ 1/4 ____ 1/4 ____ 1/4 Section ~~33~~ 34
Lot NW SW Block
Subdivision ADJACENT TO VISSER HANGER

4. PROPOSED USE Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify CROP DUSTING SUPPLY

5. DRILLING METHOD ______cable, ______bored,
X forward rotary, ______reverse rotary, ______jetted,
______other (specify)______

6. WELL CONSTRUCTION AND COMPLETION

Perforations 1/8 INCH and/or Screen

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Kind Size	From (feet)	To (feet)
8 3/4"	6 5/8" 1/4 WALL STEEL	0'	15'	1/8" 12 PER FOOT	76'	110'
8 3/4"	6 5/8" 160 PSI PVC	15'	110'			

Was casing left open end? ____Yes X No
Was a packer or seal used? X Yes ____No
If so, what material CEMENT @ 15'
Was the well gravel packed? X Yes ____No
Was the well grouted? X Yes ____No
To what depth? 15'
Material used in grouting BENTONITE SLURRY
Well head completion: Pitless adapter X Yes ____No
Top of casing 12 in. or greater above grade X Yes ____No

7. WHAT IS THE TEMPERATURE OF THE WATER?
45° Degrees Fahrenheit
☐ Measured ☒ Estimated

8. WATER LEVEL
Static water level 70' feet below land surface
If flowing; closed-in pressure ______ psi
______ gpm
Controlled by: ______ valve, ______ reducers,
______other, (specify)______

9. WELL TEST DATA ______pump ______bailer
______other, (specify) AIR PUMP
Pumping water level below land surface:
80 ft. after 2 hrs. pumping 35 gpm
80 ft. after 4 hrs. pumping 35 gpm

10. WAS WELL PLUGGED OR ABANDONED? ____Yes X No
If yes, how? ______

11. DATE COMPLETED ______

12. WELL LOG

Depth (ft.) From	To	Formation
0'	30'	SOIL, SHALE GRAVEL
30'	70'	SHALE, CLAY
70'	110'	SAND, GRAVEL, CLAY

RECEIVED
MAR 18 1986
DEPT. OF NATURAL RESOURCES
AND CONSERVATION
BILLINGS OFFICE

HD

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Date 3/18/86

Firm Name SWEETWATER DRLG. & EXPLORATION INC.
Address P.O. BOX 123 BILLINGS, MT
Signature Ted H. Williams License No. 468

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION **DNRC**
32 SOUTH EWING   HELENA, MONTANA 59620   444-6610

STATE PUBLISHING CO., HELENA, MONT.

DEPARTMENT - BUREAU COPY

M: 9277

Billings 111 1S 24E 34 CDD Yellowstone

Form No. 603 (R 6-87)

File No. ______

WELL LOG REPORT

022263

State law requires that this form be filed by the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name Harvey E AND Melody E Fox

2. CURRENT MAILING ADDRESS
8325 Airport Rd.
Laurel, Mt. 59044

3. WELL LOCATION
County Yellowstone
Township 1 [✓ S] Range 24 [✓ E] W
SE ¼ SE-SW ¼ Section 34
Lot ______ Block ______
Subdivision ______
Tract Number ______

4. PROPOSED USE Domestic ☐ Stock ☑ Irrigation ☐
Other ☐ specify ______

5. DRILLING METHOD ✓ cable, ______ air rotary, ______ forward rotary, ______ reverse rotary, ______ jetted, ______ other (specify) ______

Depth (ft.) From	To	Formation
0	5	Gravel + Sand
5	45	Sand with som Brn Clays
45	67	Clay With Sand Stringers
67	74	Sand Med fine (Water Bearing)
74	82	Sand + Gravel

ATTACH ADDITIONAL SHEETS IF NECESSARY

7. WELL CONSTRUCTION AND COMPLETION

Perforations ~~None~~ and/or Screen None

Size of drilled hole	Size and PSI Rating of casing	From (feet)	To (feet)	Kind Size	From (feet)	To (feet)
6"	6"	+2	82			
	inserted liner 1½" PVC	20	82	10 ft factory sloted casing from 72 ft to 82 ft		

Was casing left open end? ✓ Yes ______ No
Was a packer or seal used? ______ Yes ✓ No
If so, what material ______
Was the well gravel packed? ______ Yes ✓ No
To what depth was the well grouted? 82 ft
Material used in grouting Bentonite
Pitless adapter ______ Yes ______ No
Top casing 18 in. or greater above grade ✓ Yes ______ No

8. WELL TEST DATA

The pump test information request in this section is required for all wells. All depth measurements shall be from the top of the well casing unless otherwise specified.

All wells under 100 gpm must be tested for a minimum of one hour and provide the following information:

a) Air ______ Pump ✓ Bailer ______
b) Static water level immediately before testing 40 ft. If flowing; closed-in pressure ______ psi ______ gpm
Controlled by: ______ valve, ______ reducers, ______ other, (specify) ______
c) Depth at which pump is set for test 78
d) The pumping rate and means of discharge (i.e., bailing, airlift, pumping) 50 gpm
e) Maximum drawdown during the test 50 ft
f) Duration of test: Pumping time 3 hrs
Recovery time 2 hrs
g) Recovery water level 40 ft
Amount of time after pumping recovery level water data was taken 12 hrs

Wells intended to yield 100 gpm or more shall be tested for a period of 8 hours or more. The test shall follow the development of the well, and shall be conducted continuously at a constant discharge at least as great as the intended appropriation. In addition to the above information, water level data shall be collected and recorded on the Department's "Aquifer Test Data" form included in each packet of well logs.

NOTE: All wells shall be equipped with an access port ½ inch minimum or a pressure gauge that will indicate the shut-in pressure of a flowing well. Removable caps are acceptable as access ports.

9. WAS WELL PLUGGED OR ABANDONED? ______ Yes ✓ No
If yes, how? ______

10. DATE COMPLETED 11-12-87

11. DRILLER/CONTRACTOR'S CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

11-18-87
Date

KNK Well Service
Firm Name

209 6th Ave, Laurel, MT. 59044
Address

Kenneth M. Bauer 435
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION

1520 EAST SIXTH AVENUE HELENA, MONTANA 59620-2301 444-6610

DNRC

DEPARTMENT — BUREAU COPY

Billings. 111 2S 24E 03 A Yellowstone

Form No. 603 (R 2-89)

WELL LOG REPORT

File No 077519

State law requires that the Bureau's copy be filed by the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name KENNETH BEUEN

2. CURRENT MAILING ADDRESS
1730 Pinyon Dr.
LAUREL, MT. 59044

3. WELL LOCATION
_____ ¼ N ½ NE ¼ Section 3
Township 2 N/S Range 24E E/W County Yellowstone
Govn't Lot _____, or Lot 8, Block 1
Subdivision Name Collingwood
Tract Number _____

4. PROPOSED USE: Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify _____

5. TYPE OF WORK:

New well	☒	Method: Dug	☐	Bored	☐
Deepened	☐	Cable	☒	Driven	☐
Reconditioned	☐	Rotary	☐	Jetted	☐

6. DIMENSIONS: Diameter of Hole
Dia. 6 in. from 0 ft. to 34 ft.
Dia. _____ in. from _____ ft. to _____ ft.
Dia. _____ in. from _____ ft. to _____ ft.

7. CONSTRUCTION DETAILS:
Casing; Steel Dia. 6 from +2 ft. to 34 ft.
Threaded ☐ Welded ☒ Dia. _____ from _____ ft. to _____ ft.
Type _____ Wall Thickness _____
Casing; Plastic Dia. _____ from _____ ft. to _____ ft.
Weight _____ Dia. _____ from _____ ft. to _____ ft.
PERFORATIONS: Yes ☐ No ☒
Type of perforator used _____
Size of perforations _____ in. by _____ in.
_____ perforations from _____ ft. to _____ ft.
_____ perforations from _____ ft. to _____ ft.
_____ perforations from _____ ft. to _____ ft.
SCREENS: Yes ☐ No ☒
Manufacturer's Name _____
Type _____ Model No. _____
Dia. _____ Slot size _____ from _____ ft. to _____ ft.
Dia. _____ Slot size _____ from _____ ft. to _____ ft.
GRAVEL PACKED: Yes ☐ No ☒ Size of gravel _____
Gravel placed from _____ ft. to _____ ft.
GROUTED: To what depth? Continuous 34 ft.
Material used in grouting Bentonite

8. WELL HEAD COMPLETION:
Pitless Adapter ☒ Yes ☐ No

9. PUMP (If installed)
Manufacturer's name _____
Type _____ Model No. _____ HP. _____

10. WELL TEST DATA

The information requested in this section is required for all wells. All depth measurements shall be from the top of the well casing.

All wells under 100 gpm must be tested for a minimum of one hour and provide the following information:

a) Air _____ Pump ✓ Bailer _____
b) Static water level immediately before testing 24 ft. If flowing; closed-in pressure _____ psi. _____ gpm.
Flow controlled by: _____ valve, _____ reducers, _____ other, (specify) _____.
c) Depth at which pump is set for test 33 ft
d) The pumping rate: 24 gpm.
e) Pumping water level 32 ft. at 3 hrs. after pumping began.
f) Duration of test: Pumping time 3 hrs.
g) Recovery time 1 hrs.
h) Recovery water level 26 ft. at 1 hrs. after pumping stopped.

Wells intended to yield 100 gpm or more shall be tested for a period of 8 hours or more. The test shall follow the development of the well, and shall be conducted continuously at a constant discharge at least as great as the intended appropriation. In addition to the above information, water level data shall be collected and recorded on the Department's "Aquifer Test Data" form.

NOTE: All wells shall be equipped with an access port ½ inch minimum or a pressure gauge that will indicate the shut-in pressure of a flowing well. Removable caps are acceptable as access ports.

11. WAS WELL PLUGGED OR ABANDONED? _____ Yes ✓ No
If yes, how? _____

12. WELL LOG

Depth (ft.) From	To	Formation
0	1	top soil.
1	11	Clay
11	14	Sandy Clay + fine Gravel
14	19	Sand + fine Gravel
19	29	Sand
29	34	Sand + Gravel
		Drainage = HD

RECEIVED
NOV 26 1990
DEPT. OF NATURAL RESOURCES AND CONSERVATION BILLINGS OFFICE

15-90

ATTACH ADDITIONAL SHEETS IF NECESSARY

13. DATE COMPLETED 9-29-90

14. DRILLER/CONTRACTOR'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

11-17-90
Date
KAL Well Service
Firm Name
1730 Pinyon Dr. Laurel Mt.
Address
Kenneth M. Beuen 435
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION
1520 EAST SIXTH AVENUE HELENA, MONTANA 59620-2301 444-6610
DNRC

M121855

DEPARTMENT — BUREAU COPY

02S [illegible] 24E 03A

Form No. 603 R10/79

YELLOWSTONE

File No.

WELL LOG REPORT

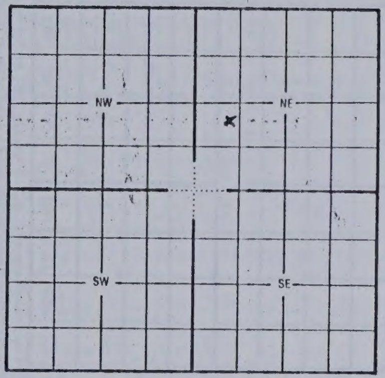
State law requires that this form be filed by the water well driller within 60 days after comple

016107

1. WELL OWNER
Name Kenneth M. Bevens

2. CURRENT MAILING ADDRESS
209 6th ave
Laurel Montana

3. WELL LOCATION



¼ N ½ NE ¼ Section 3
Township 2 N/[✓ S] Range 24 [✓ E]/W
County Yellowstone
Lot 8 Block 1
Subdivision Collingwood
Well Elevation
Accuracy: ____ ± 10'; ____ ± 50'; ____ ± 100';

4. DRILLING METHOD ✓ cable, ____ bored, ____ forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify)

5. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations and/or Screen Kind Size	From (feet)	To (feet)
6"	6" 250 Steel	0	25			

Was casing left open end? ✓ Yes ____ No
Was a packer or seal used? ____ Yes ✓ No
If so, what material
Was the well gravel packed? ____ Yes ✓ No
Was the well grouted? ____ Yes ✓ No
To what depth?
Material used in grouting
Well head completion: Pitless adapter
12 in. above grade ✓, other
(if other, specify)
Pump horsepower ☐, pump type
Pump intake level ____ feet below land surface
Power (electric, diesel, etc.)

6. WATER LEVEL
Static water level 12 feet below land surface
If flowing, closed-in pressure ____ psi
____ gpm flow through ____ inch pipe
Controlled by: ____ valve, ____ reducers, ____ other
(if other, specify)

7. WELL TEST DATA ____ pump ✓ bailer ____ other
(if other, specify)
Pumping level below land surface:
____ ft. after ____ hrs. pumping ____ gpm
____ ft. after ____ hrs. pumping ____ gpm

8. WAS WELL PLUGGED OR ABANDONED? ____ Yes ✓ No
If yes, how?

9. DATE STARTED
DATE COMPLETED

10. WELL LOG

Depth (ft.) From	To	Formation
0	4	top sail
4	10	Gravel & Rock
10	25	Gravel & Sand

HD

(use separate sheet if necessary)

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

1-28-81
Date

Beven Drilling
Firm Name

McLeod Montana 59062
Address

Thomas D Beven 294
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION
32 SOUTH EWING HELENA, MONTANA 59601 449-3634 **DNRC**

M:97981

DEPARTMENT COPY

WL - 7939

Form No. 603 R10/79 023 24E-03A File No.

S

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after compl

016106

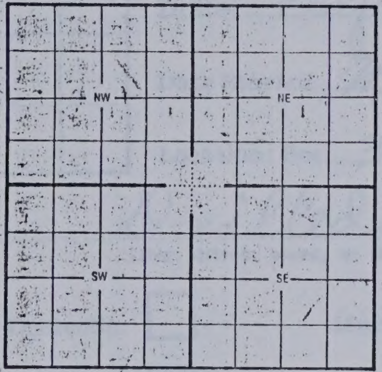
1. WELL OWNER

Name John adams

2. CURRENT MAILING ADDRESS

609 Birch ave
Laurel Montana

3. WELL LOCATION



¼ N ½ NE ¼ Section 3
Township 2 N [✓ S] Range 24 [✓ E] W
County Yellowstone
Lot 12 Block 8
Subdivision Collingwood
Well Elevation
Accuracy: ____ ± 10'; ____ ± 50'; ____ ± 100';

4. DRILLING METHOD ✓ cable, ____ bored, ____ forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify) ____

5. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations and/or Screen Kind Size	From (feet)	To (feet)
6"	6" 250 Steel	0	33			

Was casing left open end? ✓ Yes ____ No
Was a packer or seal used? ____ Yes ✓ No
If so, what material ____
Was the well gravel packed? ____ Yes ✓ No
Was the well grouted? ✓ Yes ____ No
To what depth? Below Pittless
Material used in grouting Cement
Well head completion: Pitless adapter ✓
12 in. above grade ✓, other ____
(If other, specify) ____
Pump horsepower 3, pump type Sub
Pump intake level 30 feet below land surface
Power (electric, diesel, etc.) Elec

6. WATER LEVEL

Static water level 25 feet below land surface
If flowing, closed-in pressure ____ psi
____ gpm flow through ____ inch pipe
Controlled by: ____ valve, ____ reducers, ____ other
(If other, specify) ____

7. WELL TEST DATA ✓ pump ✓ bailer ____ other
(If other, specify) ____
Pumping level below land surface:
27 ft. after 6 hrs. pumping 18 gpm
____ ft. after ____ hrs. pumping ____ gpm

8. WAS WELL PLUGGED OR ABANDONED? ____ Yes ✓ No
If yes, how? ____

9. DATE STARTED March 23
DATE COMPLETED March 24

10. WELL LOG

Depth (ft.) From	To	Formation
0	6	Top soil
6	10	Rock
10	18	Sand
18	26	Brown Clay
26	33	Sand & Gravel

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BILLINGS OFFICE

HD

(use separate sheet if necessary)

11. DRILLER'S CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

March 24
Date

Beven Drilling
Firm Name

McLeod Montana 59052
Address

Thomas D Beven
Signature

294
License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59601 449-3634

M 97980

DEPARTMENT COPY WL - 7943

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T 1S R 24E 34

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MONTANA BUREAU OF MINES AND GEOLOGY
Butte, Montana

(3)

WATER WELL LOG

Owner Jake K. Fronk Address R1. Laurel

Driller Clyde Sondo Address 1141 Mibourne Billings

Date Started May 21, 1960 Date Completed May 26, 19

Location: Sec. 34 T. 1S R. 24 ¼ sec. SE¼

Type of well Drilled (Dug, driven, bored, or drilled) Equipment used Cable (Churn drill, rotary, other)

Water use: Domestic ☐ Municipal ☐ Stock ☐ Irrigation ☐

Industrial ☐ Drainage ☐ Other: Dairy

Casing: 0 ft. to 56' 4" ft. Type 49lb surface pipe Size 10 inch

Casing: ft. to ft. Type Size

Casing: ft. to ft. Type Size

Perforated or Screened: Ft. to ft. Ft. to ft.

Type of screen or perforations

Static Water level, for non-flowing well: feet

Shut-in pressure, for flowing well: lb./sq. in. on: (date)

Pumping water level feet at 100 gal. per min.

How tested: test pump

Length of test

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

(over)

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T 1S R 24E 32

County Yellowstone

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Montana Bureau of
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STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

019225

(4)

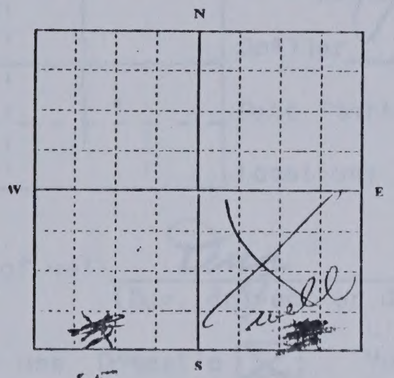
Declaration of Vested Groundwater Rights

(Under Chapter 237, Montana Session Laws, 1961)

1. [illegible], of Rt 1 [illegible]
(Name of Appropriator) (Address) (Town)

County of Yellowstone State of Mont.

have appropriated groundwater according to the Montana laws in effect prior to January 1, 1962, as follows:



SE ¼ SE Sec. 32 T. 1S R. 24E

Indicate point of appropriation and place of use, if possible. Each small square represents 10 acres.

2. The beneficial use on which the claim is based [illegible]

3. Date or approximate date of earliest beneficial use; and how continuous the use has been 1950

4. The amount of groundwater claimed (in miner's inches or gallons per minute) 20 [illegible]

5. If used for irrigation, give the acreage and description of the lands to which water has been applied and name of the owner thereof not used

6. The means of withdrawing such water from the ground and the location of each well or other means of withdrawal [illegible]

7. The date of commencement and completion of the construction of the well, wells, or other works for withdrawal of groundwater 1950

8. The depth of water table [illegible]

9. So far as it may be available, the type, size and depth of each well or the general specifications of any other works for the withdrawal of groundwater [illegible]

10. The estimated amount of groundwater withdrawn each year [illegible]

11. The log of formations encountered in the drilling of each well if available [illegible]

12. Such other information of a similar nature as may be useful in carrying out the policy of this act, including reference to book and page of any county record

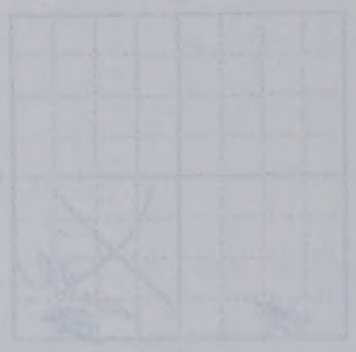
Signature of Owner [illegible]

Date [illegible] 1963

Three copies to be filed by the owner with the County Clerk and Recorder of the county in which the well is located.

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

Original to the County Clerk and Recorder; Duplicate to the State Engineer; Triplicate to the Montana Bureau of Mines and Geology, and Quadruplicate for the Appropriator.



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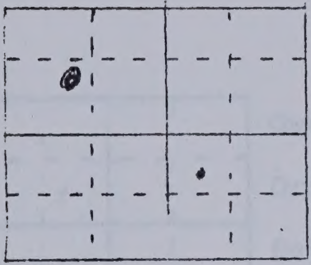
COUNTY Yellowstone

MONTANA BUREAU OF MINES AND GEOLOGY
Butte, Montana

019742

Water Well Log



Owner R J Rosselot Address Laurel

Driller ______ Address ______

Date Started 1908 Date Completed ______

Location: Sec. 4 T. 2S R. 24E ¼ Sec. SW¼ of NW¼

Type of well Dug
(Dug, driven, or drilled)

Equipment used ______
(Churn drill, rotary, other)

Water use Domestic ☒ Municipal ☐ Stock ☒ Irrigation ☐

Industrial ☐ Drainage ☐ Other ______

Casing: ______ ft. to 50 ft. Type Stone Size 4 ft

Casing: ______ ft. to ______ ft. Type ______ Size ______

Casing: ______ ft. to ______ ft. Type ______ Size ______

Perforated or screened: Ft. ______ to ft. ______ Ft. ______ to ft. ______

Type of screen or perforations ______

Static water level, for non-flowing well: 40' feet.

Shut-in pressure for flowing well: ______ lb. /sq. in. on: ______
(date)

Pumping water level 45 feet at 20 gal. per min. ______

How tested: ______

Length of test ______

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

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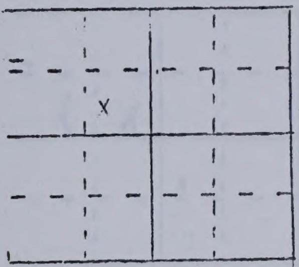
WATER WELL LOG



Owner Eugene Holland Address Rt 1 Laurel mont

Driller CA McKeehan Address Park City

Date Started 1957 Date Completed 1957

Location: Sec. 4 T. 2-S R. R24E ¼ Sec. SE¼ of NW¼

Type of well Drilled (Dug, driven, or drilled) Equipment used Churn (Churn, drill, rotary other)

Water use Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☐

Industrial ☐ Drainage ☐ Other

Casing: 50 ft. to ft. Type Iron Size 6"

Casing: ft. to ft. Type Size

Casing: ft. to ft. Type Size

Perforated or screened Ft. 10 to ft. Ft. to Ft.

Type of screen or perforations Slit

Static water level, for non-flowing well: 20 feet.

Shut-in pressure for flowing well: lb./sq. in. on: (date)

Pumping water level 30 feet at 20 gal.per.min.

How tested:

Length of test

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

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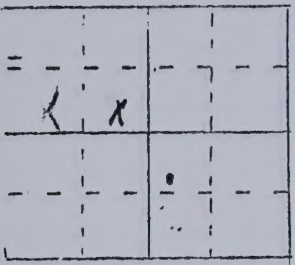
Butte, Montana

WATER WELL LOG



Owner James W Hill Address Rt 1 Box 15 Laurel Mont

Driller C.A. McKeehan Address Park City

Date Started 1957 Date Completed 1957

Location: Sec. 4 T2S R.24E ¼ Sec. SE 1/4 of NW 1/4

Type of well Drilled (Dug, driven, or drilled) Equipment used Churn (Churn, drill, rotary other)

Water use Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☒

Industrial ☐ Drainage ☐ Other

Casing: 50 ft. to ft. Type Iron Size 6"

Casing: ft. to ft. Type Size

Casing: ft. to ft. Type Size

Perforated or ~~screened~~ Ft. 10 to ft. Ft. to Ft.

Type of screen or perforations Slit

Static water level, for non-flowing well: 30 feet.

Shut-in pressure for flowing well: lb./sq. in. on: (date)

Pumping water level 40 feet at 50 gal.per.min.

How tested: Pump

Length of test 18 hrs

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

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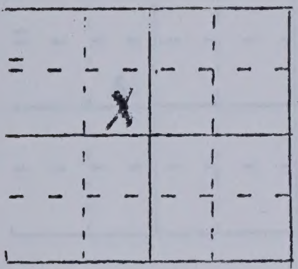
WATER WELL LOG



Owner John R Lees Address N of Laurel

Driller McKeehan Address Park City

Date Started 1957 Date Completed 1957

Location: Sec. 4 T. 2-S R. 24-E ¼ Sec. SE¼ of NW¼

Type of well Drilled (Dug, driven, or drilled) Equipment used Churn drill (Churn, drill, rotary other)

Water use Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☒
Industrial ☐ Drainage ☐ Other

Casing: 0 ft. to 39 ft. Type iron Size 6"
Casing: ft. to ft. Type Size
Casing: ft. to ft. Type Size

Perforated or screened Ft. 10 to ft. Ft. to Ft.

Type of screen or perforations holes cut in lower sec. of casing

Static water level, for non-flowing well: 16 feet.

Shut-in pressure for flowing well: lb./sq. in. on: (date)

Pumping water level 35 feet at 50 gal.per.min.

How tested: Driller tested with dip bucket

Length of test ?

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

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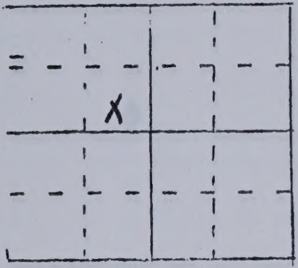
Butte, Montana

WATER WELL LOG



Owner H V Frank [illegible] Address [illegible]

Driller C A [illegible] Address [illegible]

Date Started 1957 Date Completed 1958

Location: Sec. 4 T. [illegible] R. [illegible] ¼ Sec. [illegible]

Type of well [illegible] Equipment used [illegible]
(Dug, driven, or drilled) (Churn, drill, rotary other)

Water use Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☑

Industrial ☐ Drainage ☐ Other ____

Casing: [illegible] ft. to ____ ft. Type [illegible] Size 6"

Casing: ____ ft. to ____ ft. Type ____ Size ____

Casing: ____ ft. to ____ ft. Type ____ Size ____

Perforated or screened Ft. [illegible] to ft. ____ Ft. ____ to Ft. ____

Type of screen or perforations [illegible]

Static water level, for non-flowing well: [illegible] feet.

Shut-in pressure for flowing well: ____ lb./sq. in. on: ____
(date)

Pumping water level [illegible] feet at [illegible] gal.per.min. ____

How tested: ____

Length of test ____

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

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County Yellowstone

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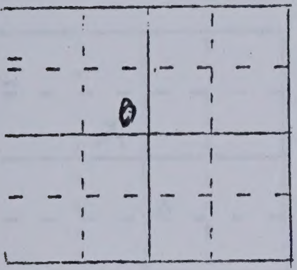
Butte, Montana

WATER WELL LOG



Owner J C Gruhlke Address Laurel

Driller Address

Date Started Date Completed

Location: Sec. 4 T. 2S R. 24E ¼ Sec. SE¼ of NW¼

Type of well (Dug, driven, or drilled) Equipment used (Churn, drill, rotary other)

Water use Domestic ☐ Municipal ☐ Stock ☐ Irrigation ☐

Industrial ☐ Drainage ☐ Other

Casing: 40 ft. to ft. Type Steel Size

Casing: ft. to -ft. Type Size

Casing: ft. to ft. Type Size

Perforated or screened Ft. to ft. Ft. to Ft.

Type of screen or perforations 6"

Static water level, for non-flowing well: 23 feet.

Shut-in pressure for flowing well: lb./sq. in. on: (date)

Pumping water level 35 feet at 100 gal.per.min.

How tested: Pump tested

Length of test 24 hr

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

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County [illegible]

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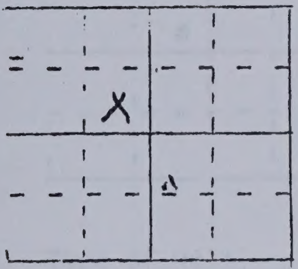
Butte, Montana

WATER WELL LOG



Owner E F Thomas Address Rt 1 Box 16 Laurel

Driller [illegible] Address Billings

Date Started 1955 Date Completed 1955

Location: Sec. 4 T. 2S R. 24E ¼ Sec. SE¼ of NW¼

Type of well Drilled Equipment used Churn
(Dug, driven, or drilled) (Churn, drill, rotary other)

Water use Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☒

Industrial ☐ Drainage ☐ Other ____

Casing: 45 ft. to ____ ft. Type Iron Size 6"

Casing: ____ ft. to ____ ft. Type ____ Size ____

Casing: ____ ft. to ____ ft. Type ____ Size ____

Perforated or screened Ft. 6 to ft. ____ Ft. ____ to Ft. ____

Type of screen or perforations ____

Static water level, for non-flowing well: 30 feet.

Shut-in pressure for flowing well: ____ lb./sq. in. on: ____
(date)

Pumping water level 40 feet at 18 gal.per.min. ____

How tested: ____

Length of test ____

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

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Yellowstone

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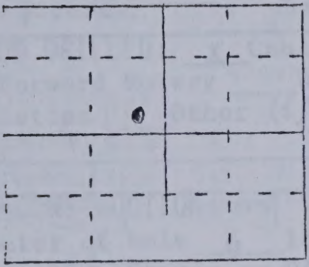
T. 2S R. 24E 4
COUNTY Yellowstone

MONTANA BUREAU OF MINES AND GEOLOGY
Butte, Montana

Water Well Log



Owner Burt L. and Cleanna M. Ward Address Rte 1, Laurel, Mont.

Driller Clyde Sando Address Billings, Montana

Date Started May 1959 Date Completed May 1959

Location: Sec. 4 T. 2S R. 24E ¼ Sec. SE 1/4 of NW 1/4

Type of well Driven
(Dug, driven, or drilled)

Equipment used Churn Drill
(Churn drill, rotary, other)

Water use Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☒
Industrial ☐ Drainage ☐ Other ____

Casing 0 ft. to 50 ft. Type XXXXX Steel Size 6"

Casing ____ ft. to ____ ft. Type ____ Size ____

Casing ____ ft. to ____ ft. Type ____ Size ____

Perforated or screened: Ft. ____ to ft. ____ Ft. ____ to ft. ____

Type of screen or perforations ____

Static water level, for non-flowing well: Twenty five feet.

Shut-in pressure for flowing well ____ lb. /sq. in. on: ____
(date)

Pumping water level 47 feet at 20 gal. per min. ____

How tested: Pump

Length of test two hours

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

Foot valve at 45 feet.

RM No. 603 New 7-73 111 02S 24E 04 BD 1 Yellowstone File No. 6563-7138

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Mines & Geology

STATE OF MONTANA
Department of Natural Resources and Conservation

WHITE —
PINK —
CANAR
GOLDENROD — DRILLER

017989

59044

WELL LOG REPORT

State law requires that this form be filed by the water well driller on any water well completed by him on and after July 1, 1973 within sixty (60) days after completion of the well.

1. WELL OWNER: Name Wallace Hill Address 1751 Coverlane Laurel, Mont.

2. WELL LOCATION: County Yellowstone ; SE¼ NW¼ ¼, Sec. 4 , Twp. 2S N-S, Rg. 24E E-W

3. PROPOSED USE: ___ Domestic ___ Stock ___ Municipal ___ Industrial ___ Lawn and Garden
X Irrigation ___ Other (*if other, specify*) ___

4. METHOD DRILLED: X Cable ___ Bored
___ Forward Rotary ___ Reverse Rotary
/ Jetted ___ Other (*if other, specify*)

5. WELL CONSTRUCTION:
Diameter of hole 6 inches. Depth 100 ft.
Casing: X Steel ___ Plastic ___ Concrete
___ Threaded X Welded ___ Other (*if other, specify*) ___
Pipe Weight: Dia.: From: To:
___ lb/ft. 6 inches 0 feet 100 feet
___ lb/ft. ___ inches ___ feet ___ feet
___ lb/ft. ___ inches ___ feet ___ feet
Was perforated pipe used? X Yes ___ No
Length of pipe perforated 10 feet
Was casing left open end? X Yes ___ No
Was a well screen installed? ___ Yes X No
Material ___ Dia. ___ inches
(*stainless steel, bronze, etc.*)
Perforation type: X slots ___ holes
Size 8" set from 88 feet to 98 feet
Size ___ set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Was a packer or seal used? ___ Yes X No
If so, what material ___
Well type: ___ Straight screen ___ Graveled
Was the well grouted? ___ Yes X No
To what depth? ___ feet
Material used in grouting ___
Well head completion: Pitless adapter X
12" above grade ___ Other ___
(*If other, specify*) ___
Was the well disinfected? ___ Yes X No

6. WATER LEVEL:
Static water level 77 ft. below land surface
If flowing: closed-in pressure ___ psi
GPM flow ___ through ___ inch pipe
Controlled by: ___ Valve ___ Reducers
___ Other, *specify* ___

7. WELL TEST DATA: ___ Pump X Bailer ___ Other
(*If other, specify*) ___
Pumping level below land surface:
77 ft. after 2 hrs. pumping 30 gpm
___ ft. after ___ hrs. pumping ___ gpm

8. WELL LOG: ELEV. —

Depth (ft.) From	Depth (ft.) To	Formation 111CLVM 112ALVM
0	33	Brown silt.
33	73	Gravel with silt in it.
73	93	Brown silt.
93	95	Sand.
95	100	Gravel with sand in it.
100	------	Shale.

(*Use separate sheet if necessary*)

9. DATE STARTED: July 18, 1975

10. DATE COMPLETED: July 28, 1975

11. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If so, how ___

12. DRILLER'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Ray Michels well drlg. 41
Driller's or Firm Name *License No.*

Box 421 Laurel, Mt.
Address

Kevin Katles July 28, 1975
Signed by *Date*

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Yellowstone

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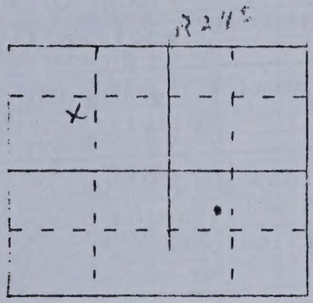
T. 2S R. 24E 4
COUNTY Yellowstone

MONTANA BUREAU OF MINES AND GEOLOGY
Butte, Montana

Water Well Log



Owner RJ Rosselot Address Laurel

Driller Sands Address Billings

Date Started 1959 Date Completed 1960

Location: Sec. 4 T. 2S R. 24E ¼ Sec. SW¼ of NW¼

Type of well drill (Dug, driven, or drilled) Equipment used drill (Churn drill, rotary, other)

Water use Domestic ☒ Municipal ☐ Stock ☒ Irrigation ☒

Industrial ☐ Drainage ☐ Other ____

Casing: ____ ft. to 50' ft. Type steel pipe Size 6"

Casing: ____ ft. to ____ ft. Type ____ Size ____

Casing: ____ ft. to ____ ft. Type ____ Size ____

Perforated or screened: Ft. ____ to ft. ____ Ft. ____ to ft. ____

Type of screen or perforations ____

Static water level, for non-flowing well: 24 feet.

Shut-in pressure for flowing well: ____ lb. /sq. in. on: ____ (date)

Pumping water level 50 feet at 20 gal. per min. ____

How tested: ____

Length of test ____

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

Foot valve at 50 ft

111 02S 24E 04 BCA Yellowstone 2S-24E-4BCA

File No. ____________

No. 603 (Rev. 3/75)

STATE OF MONTANA

Department of Natural Resources and Conservation

8558-
943Q

nt
017986
ner
Gold-Driller

②

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well, and Form 602, Notice of Completion of Groundwater Development, be filed by the well owner within 60 days after the water has been put to beneficial use.

WELL OWNER
Name Gary Pfaff
Current address 721 Wyoming, Laurel, MT

WELL LOCATION, Lot ______, Block ______, Subdivision ______
County Yellowstone, or NE ¼ SW ¼ NW ¼ Sec. 4, T. 2 N [✓ S] R. 24 [✓ E] W

PROPOSED USE x domestic (includes lawn and garden); ____ stock; ____ municipal; ____ industrial; ____ irrigation; ____ other (specify) ______

METHOD DRILLED x cable, ____ bored, ____ forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify) ______

WELL CONSTRUCTION
Diameter of hole x in.; depth ____ ft.
Casing: x steel, ____ plastic, ____ concrete, ____ threaded, x welded, ____ other (specify) ______

Pipe weight:

	Dia.	From	To
17.02 lb/ft	6 5/8 in.	+2 ft.	112 ft.
lb/ft	in.	ft.	ft.

Was casing left open end? x Yes ____ No
Was a well screen installed? ____ Yes x No
Material ______, dia. ____ in.
(stainless steel, bronze, etc.)
Was perforated pipe used? x Yes ____ No
Perforation type: x slots ____ holes
Size 3/16 set from 108 ft. to 111 ft.
Size ____ set from ____ ft. to ____ ft.
Was a packer or seal used? ____ Yes x No
If so, what material ______
Well type: ____ Straight screen ____ Graveled
Was the well grouted: ____ Yes x No
To what depth: ____ ft.
Material used in grouting ______
Well head completion: Pitless adapter ____
12 in. above grade x, other ____
(if other, specify) ______
Was well disinfected? ____ Yes x No

6. WATER LEVEL
Static water level 70 ft. below land surface
If flowing: closed-in pressure ____ psi
____ gpm flow through ____ inch pipe
Controlled by: ____ valve ____ reducers
____ other (specify) ______

7. WELL TEST DATA ____ Pump x Bailer ____ Other
(if other, specify) ______
Pumping level below land surface:
100 ft. after 4 hrs. pumping 20 gpm
____ ft. after ____ hrs. pumping ____ gpm

8. WELL LOG Two Pine School

Depth (ft) No e/e.

111CLVM
110ALVM

From	To	Formation
0	7	top soil
7	112	sand & gravel

(use separate sheet if necessary)

9. DATE STARTED 5-3-76
DATE COMPLETED 5-13-76

10. WAS WELL PLUGGED OR ABANDONED? ____ Yes x No
If so, how? ______

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

B & H Drilling No. 27
Driller's or firm name License No.

Box 32 Fishtail, MT 59028
Address

Robert B. Murphy 5-27-76
Signed by date

2S 24E 04 Yellowstone

FORM No. 603 New 7-73

Yellowstone 2S 24E 4

File No.

STATE OF MONTANA

Department of Natural Resources and Conservation

WELL LOG REPORT

Froshelle Heights Subdivision
Lot #16

RECEIVED
OCT 23 1973
Montana Bureau of

WHITE
PINK
CANA
GOLDENROD — DRILLER

016847

State law requires that this form be filed by the water well driller on any water well completed by him on and after July 1, 1973 within sixty (60) days after completion of the well.

1. WELL OWNER: Name Dave Thor Address Laurel, Mont

2. WELL LOCATION: County Yellowstone ; ¼ ¼ NW ¼ Sec. 4 , Twp. 2 N [✓ S], Rg. 24 [✓ E] W

3. PROPOSED USE: X Domestic ___ Stock ___ Municipal ___ Industrial X Lawn and Garden ___ Irrigation ___ Other (*if other, specify*)

4. METHOD DRILLED: X Cable ___ Bored ___ Forward Rotary ___ Reverse Rotary ___ Jetted ___ Other (*if other, specify*)

5. WELL CONSTRUCTION:

Diameter of hole 6 inches. Depth 109 ft.

Casing: X Steel ___ Plastic ___ Concrete ___ Threaded X Welded ___ Other (*if other, specify*)

Pipe Weight: Dia.: From: To:

18.97 lb/ft. 6⅝ inches 14 feet 109 feet

___ lb/ft. ___ inches ___ feet ___ feet

___ lb/ft. ___ inches ___ feet ___ feet

Was perforated pipe used? X Yes ___ No

Length of pipe perforated 4 feet

Was casing left open end? X Yes ___ No

Was a well screen installed? ___ Yes X No

Material ___ Dia. ___ inches (*stainless steel, bronze, etc.*)

Perforation type: X slots ___ holes

Size 1/8 X 6 set from 102 feet to 107 feet

Size ___ set from ___ feet to ___ feet

Size ___ set from ___ feet to ___ feet

Was a packer or seal used? ___ Yes ___ No

If so, what material

Well type: ___ Straight screen ___ Graveled

Was the well grouted? ___ Yes X No

To what depth? ___ feet

Material used in grouting

Well head completion: Pitless adapter ___ 12" above grade X Other ___ (*If other, specify*)

Was the well disinfected? X Yes ___ No

6. WATER LEVEL:

Static water level 80 ft. below land surface

If flowing: closed-in pressure ___ psi

GPM flow ___ through ___ inch pipe

Controlled by: ___ Valve ___ Reducers ___ Other, *specify*

7. WELL TEST DATA: ___ Pump X Bailer ___ Other (*If other, specify*)

Pumping level below land surface:

85 ft. after 3 hrs. pumping 30 gpm

___ ft. after ___ hrs. pumping ___ gpm

8. WELL LOG:

Depth (ft.)		Formation
From	To	
0	12	TOP Soil
12	93	Sand + Gravel Thin Clay lay
93	109	Sand + Gravel
		Two ft. Plug left in
		bottom of Casing to Keep
		Sand & Gravel from heaving
		up in Hole.

(*Use separate sheet if necessary*)

9. DATE STARTED: 9-19-73

10. DATE COMPLETED: 9-26-73

11. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No

If so, how

12. DRILLER'S CERTIFICATION:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge. 328-3275

B & H Drilling 27
Driller's or Firm Name *License No.*

Fishtail, Mont
Address

Red L Haugen 9-29-7
Signed by *Date*

111 02S 24E 04B

Form No. 603 (Rev. 3/75)

File No. 74

C

STATE OF MONTANA
Department of Natural Resources and Conservation

3

WELL LOG REPORT

10353-943Q

White-Department
Pink-Bureau
Y[illegible]er
C[illegible]

017981

State law requires that this form be filed by the water well driller within 60 days after completion of the well, and Form 602, Notice of Completion of Groundwater Development, be filed by the well owner within 60 days after the water has been put to beneficial use.

1. WELL OWNER
Name Fred Rodgers Current address 801 Second ave Laurel

2. WELL LOCATION Lot 19, Block 2, Subdivision Beartooth View
County Yellowstone or ___ ¼ ___ ¼ NW ¼ Sec. 4, T. 2 N-[✓ S] R. 24 [✓ E]-W

3. PROPOSED USE ___ domestic (includes lawn and garden); ___ stock; ___ municipal; ___ industrial; ___ irrigation; ___ other (specify) ~~MAN~~
LAUREL

4. METHOD DRILLED ___ cable, ___ bored, X forward rotary, ___ reverse rotary, ___ jetted, ___ other (specify) ___

5. WELL CONSTRUCTION
Diameter of hole 6¾ in.; depth 130 ft.
Casing: ___ steel, X plastic, ___ concrete, ___ threaded, ___ welded, ___ other (specify) ___
Pipe weight: Dia. 4 From +1 To 130
260 lb/ft ___ in. ___ ft. ___ ft.
___ lb/ft ___ in. ___ ft. ___ ft.
Was casing left open end? ___ Yes ___ No
Was a well screen installed? ___ Yes X No
Material ___, dia. ___ in.
(stainless steel, bronze, etc.)
Was perforated pipe used? ___ Yes X No
Perforation type: ___ slots ___ holes
Size ___ set from ___ ft. to ___ ft.
Size ___ set from ___ ft. to ___ ft.
Was a packer or seal used? X Yes ___ No
If so, what material plastic
Well type: X Straight screen ___ Graveled
Was the well grouted: X Yes ___ No
To what depth: 14' ft.
Material used in grouting Bentonite
Well head completion: Pitless adapter ___
12 in. above grade X, other ___
(if other, specify) ___
Was well disinfected? ___ Yes ___ No

6. WATER LEVEL
Static water level 10 ft. below land surface
If flowing: closed-in pressure ___ psi
gpm flow ___ through ___ inch pipe
Controlled by: ___ valve ___ reducers
___ other (specify) ___

7. WELL TEST DATA X Pump ___ Bailer ___ Other
(if other, specify) ___
Pumping level below land surface:
120 ft. after 8 hrs. pumping 15 gpm
___ ft. after ___ hrs. pumping ___ gpm

8. WELL LOG

NO Elev.

Depth (ft) From	To	Formation
0	3	top soil
3	33	gravel
33	115	sand clay
115	116	rock
116	150	sand clay

ELEV 3323

~~110 [illegible] 111~~
~~211 CLRD~~
111CLVM.

(use separate sheet if necessary)

9. DATE STARTED 10-1-76
DATE COMPLETED 10-3-76

10. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If so, how? ___

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Rock Creek Drilling 380
Driller's or firm name License No.

PO Box 141 Joliet Mont
Address

Wm Kiepfer 10-18-76
Signed by date

(Rev. 3/78) File No.

STATE OF MONTANA

Department of Natural Resources and Conservation

WELL LOG REPORT

10293

01279A

[illegible] requires that this form be filed by the water well driller within [illegible] completion of the well, and Form 602, Notice of Completion of Groundwater Development, be filed by the well owner within 60 days after the water has been put to beneficial use.

WELL OWNER: Name [illegible] Current address [illegible]

WELL LOCATION: Lot [illegible], Block 2, Subdivision [illegible]

County [illegible], ___ ¼ ___ ¼ ___ ¼ Sec. [illegible] T. [illegible]

PROPOSED USE: ___ domestic (includes lawn and garden); ___ stock; ___ municipal; ___ industrial; ___ irrigation; ___ other (specify)

METHOD DRILLED: ___ cable, ___ bored, ___ forward rotary, ___ reverse rotary, ___ jetted, ___ other (specify)

WELL CONSTRUCTION:
Diameter of hole 6¾ in.; depth 170 ft.
Casing: ___ steel, X plastic, ___ concrete, ___ threaded, ___ welded, ___ other (specify)

Diameter:
___ in. dia. from +1 To 120
___ in. dia. from ___ ft. to ___ ft.
___ in. dia. from ___ ft. to ___ ft.
Was casing left open end? ___ Yes ___ No
Was a well screen installed? ___ Yes X No
Material ___, dia. ___ in.
(stainless steel, bronze, etc.)
Was perforated pipe used? ___ Yes X No
Perforation type? ___ slots ___ holes
Size of perforations ___ ft. to ___ ft.
Size perforated from ___ ft. to ___ ft.
Was a packer or seal used? X Yes ___ No
If so, what material [illegible]
Well X straight screen ___ Gravel packed
Was the well grouted? X Yes ___ No
To what depth? [illegible] ft.
Material used in grouting [illegible]
Well head completion: Pitless adapter ___
12 in. above grade X; other ___
(if other, specify)
Was well disinfected? ___ Yes ___ No

WATER LEVEL:
Static water level [illegible] ft. below land surface
If flowing: closed in pressure ___ psi
___ gpm flow through ___ inch pipe
Controlled by: ___ valve ___ reducers
___ other (specify)

Test pump X Pump ___ Bailer ___ Other
(if other, specify)
Pumping level below land surface:
[illegible] ft. after X hrs pumping 15 gpm
___ ft. after ___ hrs pumping ___ gpm

8. WELL LOG

Depth (ft) From	To	Formation
0	5	[illegible]
5	55	[illegible]
55	[illegible]	[illegible]
[illegible]	146	[illegible]
146	170	[illegible]

(use separate sheet if necessary)

9. DATE STARTED 10-1-84
DATE COMPLETED 10-2-84

10. WAS WELL PLUGGED OR ABANDONED? ___ Yes ___ No
If so, how?

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

[illegible]
Driller's or firm name License No.

[illegible]
Address

[illegible]
Signed by Date

Yellowstone T2S-R24E-4

No. 603, New 7-73

File No. ____

STATE OF MONTANA
Department of Natural Resources and Conservation

roshelle Heights Subdivision
lat # 12

WELL LOG REPORT

RECEIVED
OCT 23 1973

WHITE — DEPARTMENT
PINK —
CANARY
GOLDENROD — DRILLER

017982

State law requires that this form be filed by the water well driller on any water well completed by him on and after July 1, 1973 within sixty (60) days after completion of the well.

WELL OWNER: Name Herman K. Frank Address Laurel, Mont 301 FOREST AVENUE

WELL LOCATION: County Yellowstone ; ¼ ¼ NW¼, Sec. 4 , Twp. 2 N/[✓ S], Rg. 24 [✓ E]/W

PROPOSED USE: X Domestic ___ Stock ___ Municipal ___ Industrial X Lawn and Garden ___ Irrigation ___ Other (*if other, specify*) ____

METHOD DRILLED: X Cable ___ Bored ___ Forward Rotary ___ Reverse Rotary ___ Jetted ___ Other (*if other, specify*) ____

WELL CONSTRUCTION:
Diameter of hole X inches. Depth 105 ft.
Casing: X Steel ___ Plastic ___ Concrete ___ Threaded X Welded ___ Other (*if other, specify*) ____

Pipe Weight:	Dia.:	From:	To:
8.97 lb/ft.	6⅝ inches	1+ feet	100 feet
lb/ft.	inches	feet	feet
lb/ft.	inches	feet	feet

Was perforated pipe used? X Yes ___ No
Length of pipe perforated 4 feet
Was casing left open end? X Yes ___ No
Was a well screen installed? ___ Yes X No
Material ____ Dia. ____ inches
(*stainless steel, bronze, etc.*)
Perforation type: X slots ___ holes
Size 1/8 X 6 set from 95 feet to 99 feet
Size ____ set from ____ feet to ____ feet
Size ____ set from ____ feet to ____ feet
Was a packer or seal used? ___ Yes X No
If so, what material ____
Well type: ___ Straight screen ___ Graveled
Was the well grouted? ___ Yes X No
To what depth? ____ feet
Material used in grouting ____
Well head completion: Pitless adapter X
12" above grade X Other ____
(*If other, specify*) ____
Was the well disinfected? X Yes ___ No

WATER LEVEL:
Static water level 80 ft. below land surface
If flowing: closed-in pressure ____ psi
GPM flow ____ through ____ inch pipe
Controlled by: ___ Valve ___ Reducers ___ Other, *specify* ____

WELL TEST DATA: ___ Pump X Bailer ___ Other
(*If other, specify*) ____
Pumping level below land surface:
85 ft. after 2 hrs. pumping 20 gpm
____ ft. after ____ hrs. pumping ____ gpm

8. WELL LOG:

Depth (ft.) From	Depth (ft.) To	Formation
0	2	TOP Soil
2	25	Sand + Gravel
25	91	Sand with Layers of Clay
91	99	Fine Sand + Gravel (water)
		This is the only
		location on the plat.

(*Use separate sheet if necessary*)

9. DATE STARTED: 9-14-73

10. DATE COMPLETED: 9-19-73

11. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If so, how ____

12. DRILLER'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

B + H Drilling 27
Driller's or Firm Name License No.

Fishtail, Mont
Address

Red L. Haugen 9-29-73
Signed by Date

Form No. 603 (Rev. 3/75)

File No. 17000-9430

White-Department

017985

RECEIVED
JAN 1 8 1978
MONT. DEPT. OF NATURAL RESOURCES & CONSERVATION

CODED

STATE OF MONTANA
Department of Natural Resources and Conservation

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well, and Form 602, Notice of Completion of Groundwater Development, be filed by the well owner within 60 days after the water has been put to beneficial use.

1. WELL OWNER Name ______ Current address LAUREL-MONT

2. WELL LOCATION Lot 11, Block 1-2-3 Amended Subdivision [illegible] Heights
County YELLOWSTONE, or NW ¼ ____ ¼ ____ ¼ Sec. 4, T. 2 N-S, R. 24 E-W

3. PROPOSED USE X domestic (includes lawn and garden); ____ stock; ____ municipal; ____ industrial; ____ irrigation; ____ other (specify) ______

4. METHOD DRILLED ____ cable, ____ bored, X forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify) ______

5. WELL CONSTRUCTION
Diameter of hole 7 7/8 in.; depth 100 ft.
Casing: ____ steel, X plastic, ____ concrete, ____ threaded, ____ welded, ____ other (specify) ______
Pipe weight: Plastic
____ lb/ft Dia. 5" in. From 0 ft. To 100 ft.
____ lb/ft ____ in. ____ ft. ____ ft.
____ lb/ft ____ in. ____ ft. ____ ft.
Was casing left open end? X Yes ____ No
Was a well screen installed? ____ Yes X No
Material ______, dia. ____ in.
(stainless steel, bronze, etc.)
Was perforated pipe used? X Yes ____ No
Perforation type: 1/8 slots ____ holes
Size 5" set from 95 ft. to 100 ft.
Size ____ set from ____ ft. to ____ ft.
Was a packer or seal used? X Yes ____ No
If so, what material Rubber-cement
Well type: ____ Straight screen ____ Graveled
Was the well grouted: ____ Yes X No
To what depth: ____ ft.
Material used in grouting ______
Well head completion: Pitless adapter X
12 in. above grade X, other ______
(if other, specify) ______
Was well disinfected? X Yes ____ No

6. WATER LEVEL
Static water level 25 ft. below land surface
If flowing: closed-in pressure ____ psi
gpm flow ____ through ____ inch pipe
Controlled by: ____ valve ____ reducers ____ other (specify) ______

7. WELL TEST DATA ____ Pump X Bailer ____ Other
(if other, specify) ______
Pumping level below land surface:
75 ft. after 1 hrs. pumping 15 gpm
____ ft. after ____ hrs. pumping ____ gpm

8. WELL LOG

Depth (ft) From	To	Formation
0	9'	SOIL
9	20	mixed Gravel & clay
20	30	YELLOW CLAY
30	95	SHALE
95	100'	GRAVEL & SAND

(use separate sheet if necessary)

9. DATE STARTED 8/20/75
DATE COMPLETED 8/21/75

10. WAS WELL PLUGGED OR ABANDONED? ____ Yes X No
If so, how? ______

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Roy D. Perel — 170
Driller's or firm name — License No.

Billings Mont
Address

Roy D. Perel — 8/30/75
Signed by — date

ORM No. 6_3_ 111 New 7-73 ~~[illegible]~~ 02S 24E 04B

File No.________

YELLOWSTONE

Troshelle Heights Subdivision
Lot #16

STATE OF MONTANA
Department of Natural Resources and Conservation

WHITE — DEPARTMENT
PINK — BUREAU
CANARY — WELL OWNER
GOLDENROD — DRILLER

WELL LOG REPORT

State law requires that this form be filed by the water well driller on an[illegible] 016127 completed by him on and after July 1, 1973 within sixty (60) days after compl[illegible] of the well.

1. WELL OWNER: Name Dave Thor ✓ Address Laurel, Mont

2. WELL LOCATION: County Yellowstone; ¼ ¼ NW, Sec. 4, Twp. 2 N [✓ S] Rg. 24 [✓ E] W

3. PROPOSED USE: X Domestic ___ Stock ___ Municipal ___ Industrial X Lawn and Garden ___ Irrigation ___ Other (*if other, specify*)________

4. METHOD DRILLED: X Cable ___ Bored ___ Forward Rotary ___ Reverse Rotary ___ Jetted ___ Other (*if other, specify*)________

5. WELL CONSTRUCTION:

Diameter of hole 6 inches. Depth 109 ft.

Casing: X Steel ___ Plastic ___ Concrete ___ Threaded X Welded ___ Other (*if other, specify*)

Pipe Weight: Dia.: From: To:

18.97 lb/ft. 6 5/8 inches 1+ feet 109 feet

___ lb/ft. ___ inches ___ feet ___ feet

___ lb/ft. ___ inches ___ feet ___ feet

Was perforated pipe used? X Yes ___ No

Length of pipe perforated 4 feet

Was casing left open end? X Yes ___ No

Was a well screen installed? ___ Yes X No

Material________ Dia.___ inches (*stainless steel, bronze, etc.*)

Perforation type: X slots ___ holes

Size 1/8 X 6 set from 102 feet to 107 feet

Size ___ set from ___ feet to ___ feet

Size ___ set from ___ feet to ___ feet

Was a packer or seal used? ___ Yes ___ No

If so, what material________

Well type: ___ Straight screen ___ Graveled

Was the well grouted? ___ Yes X No

To what depth?________ feet

Material used in grouting________

Well head completion: Pitless adapter________

12" above grade X Other________

(*If other, specify*)________

Was the well disinfected? X Yes ___ No

6. WATER LEVEL:

Static water level 80 ft. below land surface

If flowing: closed-in pressure ___ psi

GPM flow ___ through ___ inch pipe

Controlled by: ___ Valve ___ Reducers ___ Other, *specify*________

7. WELL TEST DATA: ___ Pump X Bailer ___ Other

(*If other, specify*)________

Pumping level below land surface:

85 ft. after 3 hrs. pumping 30 gpm

___ ft. after ___ hrs. pumping ___ gpm

8. WELL LOG:

Depth (ft.)		Formation
From	To	
0	12	TOP Soil
12	93	Sand + Gravel Thin Clay lay'i
93	109	Sand + Gravel
		Two ft Plug left in buttom of Casing to Keep Sand + Gravel from heaving up the Hole.

(*Use separate sheet if necessary*)

9. DATE STARTED: 9-19-73

10. DATE COMPLETED: 9-26-73

11. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If so, how________

12. DRILLER'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

328-3275

B+H Drilling 27
Driller's or Firm Name License No.

Fishtail, Mont
Address

Red L Haugan 9-29-7
Signed by Date

NW

File No. 111 02S 24E 04B

TRIPLICATE Yellowstone

83138

RECEIVED
AUG 5 1966
Montana Bureau of
Mines and Geology

(1)

T. 2S R. 24E 4

County Yellowstone

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

017983

Notice of Completion of Groundwater Appropriation by Means of Well

(Under Chapter 237, Montana Session Laws, 1961)

Top of Ground

(Elev. above sea level 3280)

first 27 ft gravel
27=36 sand and gravel
36=65 yellow clay
65=78 sand
78=96 gravel

Owner Rudy Groshell Address Laurel mont

Driller Adolph Koenig Address Billings mont

Date of Notice of Appropriation of Groundwater June 4-66

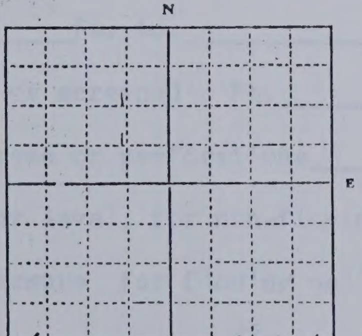
Date well started June 20 Date Completed June 24-66

Type of well drilled (dug, driven, bored or drilled) Equipment Used Cable Tool (Churn, drill, rotary or other)

Water Use: Domestic ☒ Municipal ☐ Other ☐ Irrigation ☐ Industrial ☐ Drainage ☐ Stock ☐

☞ Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS		
				Kind Size	From (Feet)	To (Feet)
6 3/4	15 1/2 lb	top	96	none	none	( )



Lot 12 7 [illegible] Blks 1 To 3 Groshell Hgts Sub
NW ¼ Sec. 4 T. 2S R. 24E
Indicate location of well and place of use, if possible. Each small square represents 10 acres.

96 Show exact depth of bottom.

Static Water Level for non-flowing Well 70 ft from Surface feet.

Shut-in Pressure for Flowing Well none

Pumping Water Level 80 ft from Surface feet at 15 gal. per minute.

Discharge in gal. per min. of flowing well none

How Tested bailer and pump Length of Test 3 hrs

Remarks: (Gravel packing, cementing, packers, type of shutoff, location of place of use of groundwater if not at well, and any other similar pertinent information, including number of acres irrigated, if used for irrigation) none

A 132
Driller's License Number

Adolph Koenig
Driller's Signature

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located.

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

Original to the County Clerk and Recorder; duplicate to the State Engineer; Triplicate to the Montana Bureau of Mines and Geology and Quadruplicate for the Appropriator.

111 02S 24E 04BB
Yellowstone

RECEIVED
JAN - 3 1982
Montana Bureau of
Mines and Geology

4

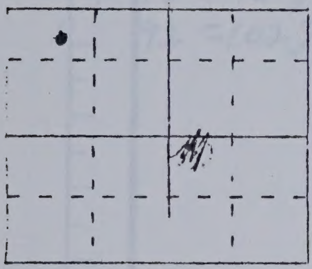
019741

Form No. 18
8-60

T. 2 S. R. 24E 4
COUNTY Yellowstone

MONTANA BUREAU OF MINES AND GEOLOGY
Butte, Montana

Water Well Log



Owner R P Rosselot Address Jarrel

Driller [illegible] Address [illegible]

Date Started [illegible] Date Completed [illegible]

Location: Sec. 4 T. 2S R. 24E ¼ Sec. NW¼ of NW¼

Type of well drilled Equipment used drill
(Dug, driven, or drilled) (Churn drill, rotary, other)

Water use Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☒
Industrial ☐ Drainage ☐ Other ____

Casing: ____ ft. to 75 ft. Type metal Size 4"

Casing: ____ ft. to ____ Ft. Type ____ Size ____

Casing: ____ ft. to ____ ft. Type ____ Size ____

Perforated or screened: Ft. ____ to ft. ____ Ft. ____ to ft. ____

Type of screen or perforations ____

Static water level, for non-flowing well: ____ feet.

Shut-in pressure for flowing well: ____ lb. /sq. in. on: ____ (date)

Pumping water level [redacted] 50 feet at 20 gal. per min. ____

How tested: ____

Length of test ____

Remarks: (Gravel packing, cementing, packers, type of shut-off, depth of shut-off)

Foot valve @ 50 ft

Gw2 111 02S 24E 04B[illegible]C

File No. Yellowstone

TRIPLICATE

RECEIVED
OCT 7 1966
Montana Bureau of Mines and Geology

(1)

T. 2S R. 24E 4

County Yellowstone

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER
OFFICE OF STATE ENGINEER

017990

Notice of Completion of Groundwater Appropriation by Means of Well

(Under Chapter 237, Montana Session Laws, 1961)

Top of Ground

(Elev. above sea level 3990)

first 34 - ft Sand and gravel
34 = 56 yellow clay
56 = 78 Sand and clay
78 = 92 yellow clay
92 = 102 gravel

Owner Kennith Chreiber Address Laurelmont

Driller Adolph Koenig Address Billings "

Date of Notice of Appropriation of Groundwater July 15-66

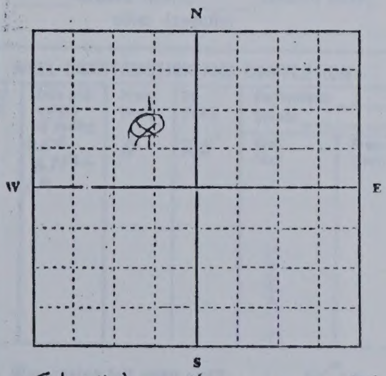
Date well started July 24 Date Completed Aug 1-66

Type of well Drilled (dug, driven, bored or drilled) Equipment Used Cable Tool (Churn, drill, rotary or other)

Water Use: Domestic ☒ Municipal ☐ Other ☐ Irrigation ☐
Industrial ☐ Drainage ☐ Stock ☐

☞ Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS		
				Kind Size	From (Feet)	To (Feet)
6 in	6 I.D. 15 lb	top	102	none	none	none



SW 1/4 NW Sec. 4 T. 2S R. 24E
Indicate location of well and place of use, if possible. Each small square represents 10 acres.

Show exact depth of bottom.

102

Static Water Level for non-flowing Well 64 feet.

Shut-in Pressure for Flowing Well none

Pumping Water Level 80 feet at 15 gal. per minute.

Discharge in gal. per min. of flowing well none

How Tested Bailer Length of Test 2 1/2 hr

Remarks: (Gravel packing, cementing, packers, type of shutoff, location of place of use of groundwater if not at well, and any other similar pertinent information, including number of acres irrigated, if used for irrigation)

165
Driller's License Number

Adolph Koenig
Driller's Signature

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located.

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

Original to the County Clerk and Recorder; duplicate to the State Engineer; Triplicate to the Montana Bureau of Mines and Geology and Quadruplicate for the Appropriator.

Form No. 603 R10/79 111 025 24E 03 A Yellowstone File No. C30648

Log filmed

WELL LOG REPORT

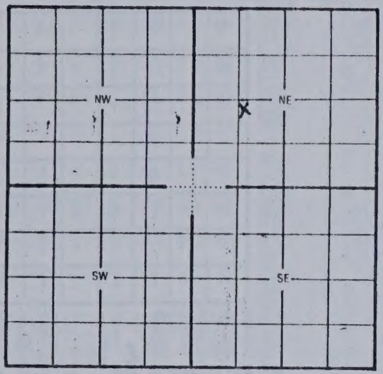
State law requires that this form be filed by the water well driller within 60 days after completion of the well.

016108

1. WELL OWNER
Name Larry Wyman

2. CURRENT MAILING ADDRESS
116 6th ave Laurel Montana

3. WELL LOCATION



¼ N 1/2¼ NE ¼ Section 3
Township 2S N/S Range 24 E E/W
County Yellowstone
Lot 7 Block 1
Subdivision COLLING WOOD
Well Elevation
Accuracy: ____ ± 10'; ____ ± 50'; ____ ± 100';

4. DRILLING METHOD [✓ cable]; ____ bored, ____ forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify)

5. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations and/or Screen: Kind Size	From (feet)	To (feet)
6"	250 STEEL 6"	0	25			

Was casing left open end? [✓ Yes] No
Was a packer or seal used? Yes [✓ No]
If so, what material
Was the well gravel packed? Yes [✓ No]
Was the well grouted? Yes [✓ No]
To what depth?
Material used in grouting
Well head completion: Pitless adapter
12 in. above grade ✓, other
(If other, specify)
Pump horsepower ☐, pump type
Pump intake level ____ feet below land surface
Power (electric, diesel, etc.)

6. WATER LEVEL
Static water level 12 feet below land surface
If flowing, closed-in pressure ____ psi
____ gpm flow through ____ inch pipe
Controlled by: ____ valve, ____ reducers, ____ other
(If other, specify)

7. WELL TEST DATA ____ pump [✓ bailer] ____ other
(If other, specify)
Pumping level below land surface:
18 ft. after ____ hrs. pumping 12 gpm
____ ft. after ____ hrs. pumping ____ gpm

8. WAS WELL PLUGGED OR ABANDONED? ____ Yes [✓ No]
If yes, how?

9. DATE STARTED 23 June 1980
DATE COMPLETED 26 June 1980

10. WELL LOG

Depth (ft.) From	To	Formation
0	7	top soil
7	15	Rock & Gravel
15	25	SAND & Gravel
25	40	Shale

(use separate sheet if necessary)

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
June 29 1980
Date
Bever Drilling
Firm Name
1113 St Johnson Billings
Address
Thomas D Bever 294
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59601 449-3634

WL - 1387

DEPARTMENT COPY

GW 4

File No. 111 02S 24E 03 BBB

TRIPLICATE Yellowstone

T. 2 S. R. 24 E. 3

County Yellowstone

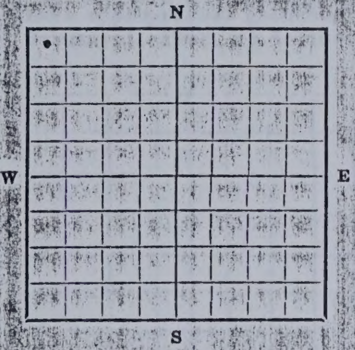
019737

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

Declaration of Vested Groundwater Rights

(Under Chapter 237, Montana Session Laws, 1961)

1. Henry Foos (Name of Appropriator), of Box XXX 252 Rte. #1 (Address) Laurel (Town)
County of Yellowstone State of Montana
have appropriated groundwater according to the Montana laws in effect prior to January 1, 1962, as follows:



NW 1/4 Sec. XX 3 T.2S R24 E.

Indicate point of appropriation and place of use, if possible. Each small square represents 10 acres.

2. The beneficial use on which the claim is based Home and cattle

3. Date or approximate date of earliest beneficial use; and how continuous the use has been 1941 continuous

4. The amount of groundwater claimed (in miner's inches or gallons per minute) 10 gallons per minute

5. If used for irrigation, give the acreage and description of the lands to which water has been applied and name of the owner thereof none

6. The means of withdrawing such water from the ground and the location of each well or other means of withdrawal pump, electric motor

7. The date of commencement and completion of the construction of the well, wells, or other works for withdrawal of groundwater 1941

8. The depth of water table 45 XX feet

9. So far as it may be available, the type, size and depth of each well or the general specifications of any other works for the withdrawal of groundwater 6" casing 70' depth

10. The estimated amount of groundwater withdrawn each year 900,000

11. The log of formations encountered in the drilling of each well if available Not Avaliable

12. Such other information of a similar nature as may be useful in carrying out the policy of this act, including reference to book and page of any county record None

Signature of Owner Henry Foos

Date December 10, 1962

Three copies to be filed by the owner with the County Clerk and Recorder of the county in which the well is located.

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

Original to the County Clerk and Recorder; duplicate to the State Engineer; Triplicate to the School of Mines and Quadruplicate for the Appropriator.

111 . 01S 24E 29BC Yellowstone

File No..................

T....1S....R....24E....29

County....Yellowstone....

019220

(4)

ORIGINAL RECEIVED
JAN 2 1964
Montana Bureau of Mines and Geology

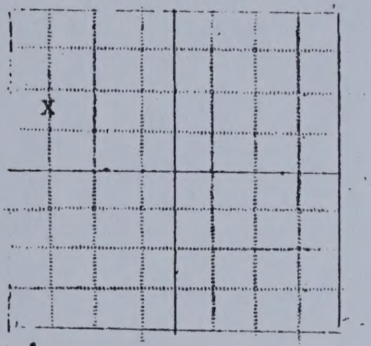
STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

DECLARATION of VESTED GROUNDWATER RIGHTS
(Under Chapter 237, Montana Session Laws, 1961)

1. **Jake W. Kukes** (Name of Appropriator), of **Laurel** (Address) (Town)

County of **Yellowstone** State of **Montana**

have appropriated groundwater according to the Montana laws in effect prior to January 1, 1962, as follows:



NW¼ ¼ Sec. **29** T. **1S** R. **23E.**

Indicate point of appropriation and place of use, if possible. Each small square represents 10 acres.

2. The beneficial use on which the claim is based **dug well - domestic and livestock**

3. Date or approximate date of earliest beneficial use; and how continuous the use has been **1947 continuous**

4. The amount of groundwater claimed (in miner's inches or gallons per minute **25 gallons**

5. If used for irrigation, give the acreage and description of the lands to which water has been applied and name of owner thereof **not applicable**

6. The means of withdrawing such water from the ground and the location of each well or other means of withdrawal **piped - pump**

7. The date of commencement and completion of the construction of the well, wells, or other works for withdrawal of groundwater **1947 - piped & pumped**

8. The depth of water table **18 feet**

9. So far as it may be available, the type, size and depth of each well or the general specifications of any other works for the withdrawal of groundwater **not applicable**

10. The estimated amount of groundwater withdrawn each year **11,169,000** gallon

11. The log of formations encountered in the drilling of each well if available **not known**

12. Such other information of a similar nature as may be useful in carrying out the policy of this act, including reference to book and page of any county record **well used since homesteaded**

Signature of Owner x

Date **December [illegible], 1963**

Three copies to be filed by the owner with the County Clerk and Recorder of the county in which the well is located.

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

Original to the County Clerk & Recorder; Duplicate to the State Engineer; Triplicate to the Montana Bureau of mines and Geology, and Quadruplicate for the appropriator

APPENDIX B

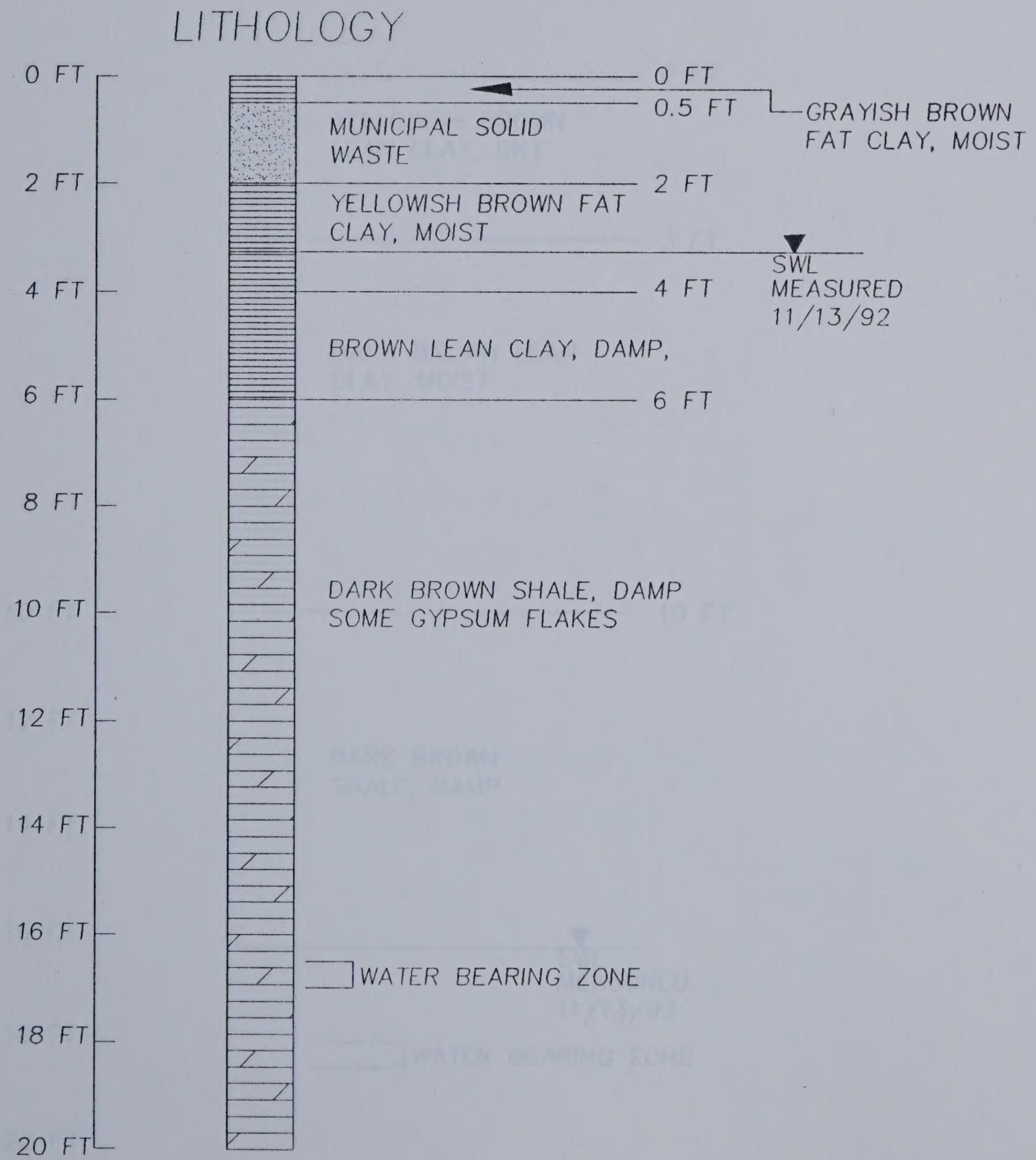
LOGS OF TEST BORINGS

LITHOLOGIC – LOG OF TEST BORING

PROJECT NUMBER 112035
SITE LAUREL LANDFILL
LOCATION LAUREL, MT
T1S, R24E, SECS 32 & 33

SUPERVISOR CURT COOVER
GEORESEARCH, INC.
DRILLER PRO PUMP
DATE OCTOBER 27, 1992

HOLE I.D.
MW-1



GEO RESEARCH

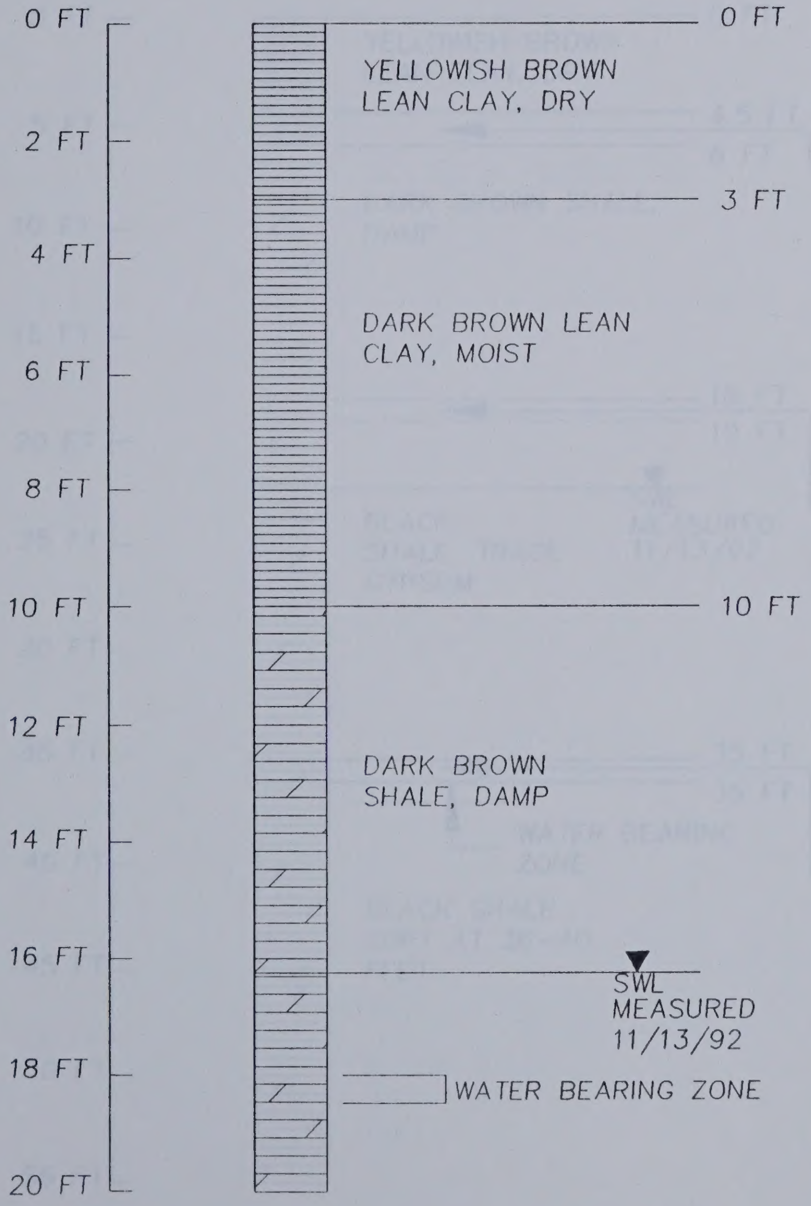
LITHOLOGIC – LOG OF TEST BORING

PROJECT NUMBER 112035
SITE LAUREL LANDFILL
LOCATION LAUREL, MT
T1S, R24E, SECS 32 & 33

SUPERVISOR CURT COOVER
GEORESEARCH, INC.
DRILLER PRO PUMP
DATE OCTOBER 27, 1992

HOLE I.D.
MW–2

LITHOLOGY



GEO
RESEARCH

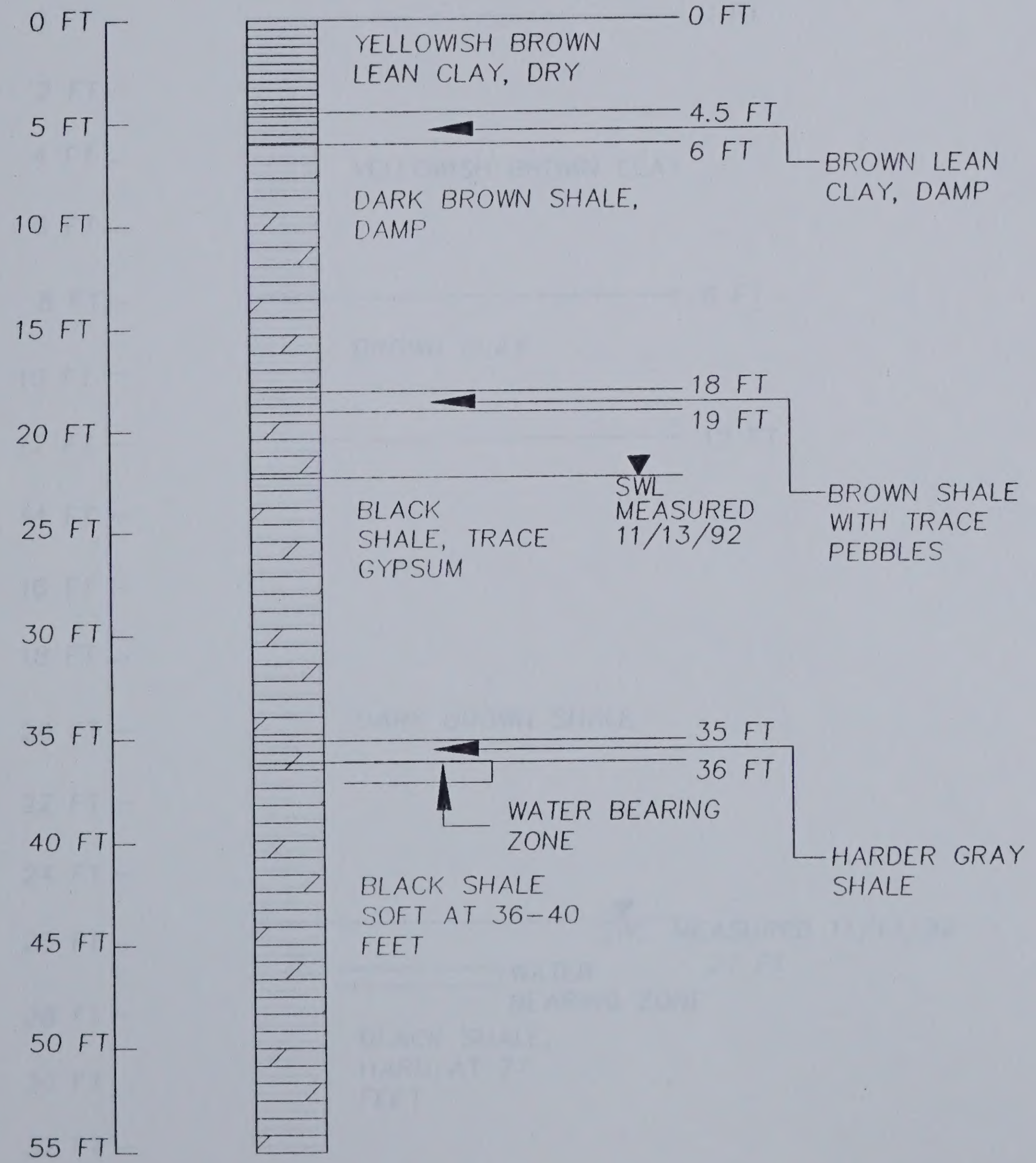
LITHOLOGIC – LOG OF TEST BORING

PROJECT NUMBER 112035
SITE LAUREL LANDFILL
LOCATION LAUREL, MT
T1S, R24E, SECS 32 & 33

SUPERVISOR CURT COOVER
GEORESEARCH, INC.
DRILLER PRO PUMP
DATE OCTOBER 27, 1992

HOLE I.D.
MW–3

LITHOLOGY



GEO RESEARCH

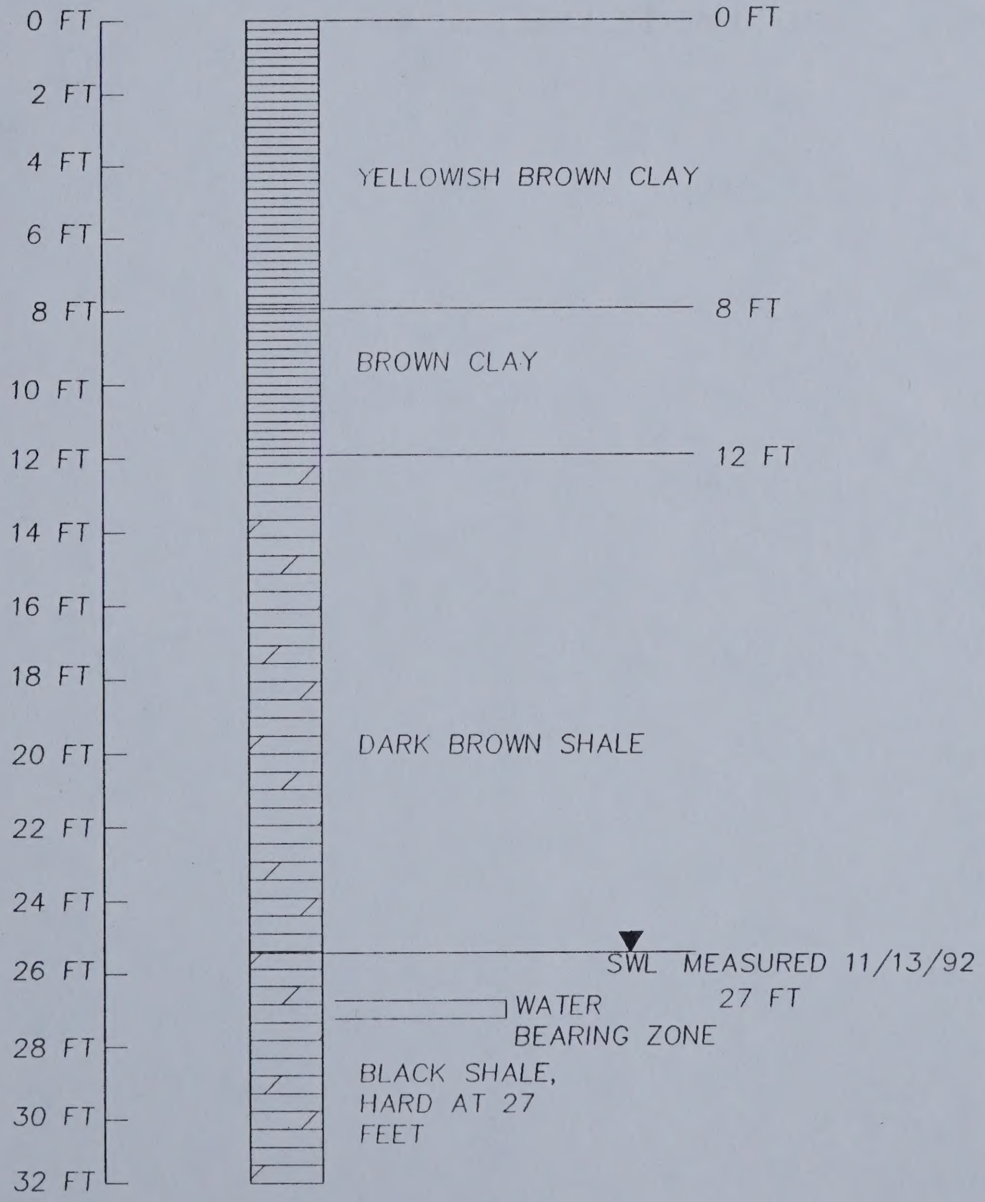
LITHOLOGIC – LOG OF TEST BORING

PROJECT NUMBER 112035
SITE LAUREL LANDFILL
LOCATION LAUREL, MT
T1S, R24E, SECS 32 & 33

SUPERVISOR CURT COOVER
GEORESEARCH, INC.
DRILLER PRO PUMP
DATE OCTOBER 28, 1992

HOLE I.D.
MW–4

LITHOLOGY



GEO RESEARCH

APPENDIX C

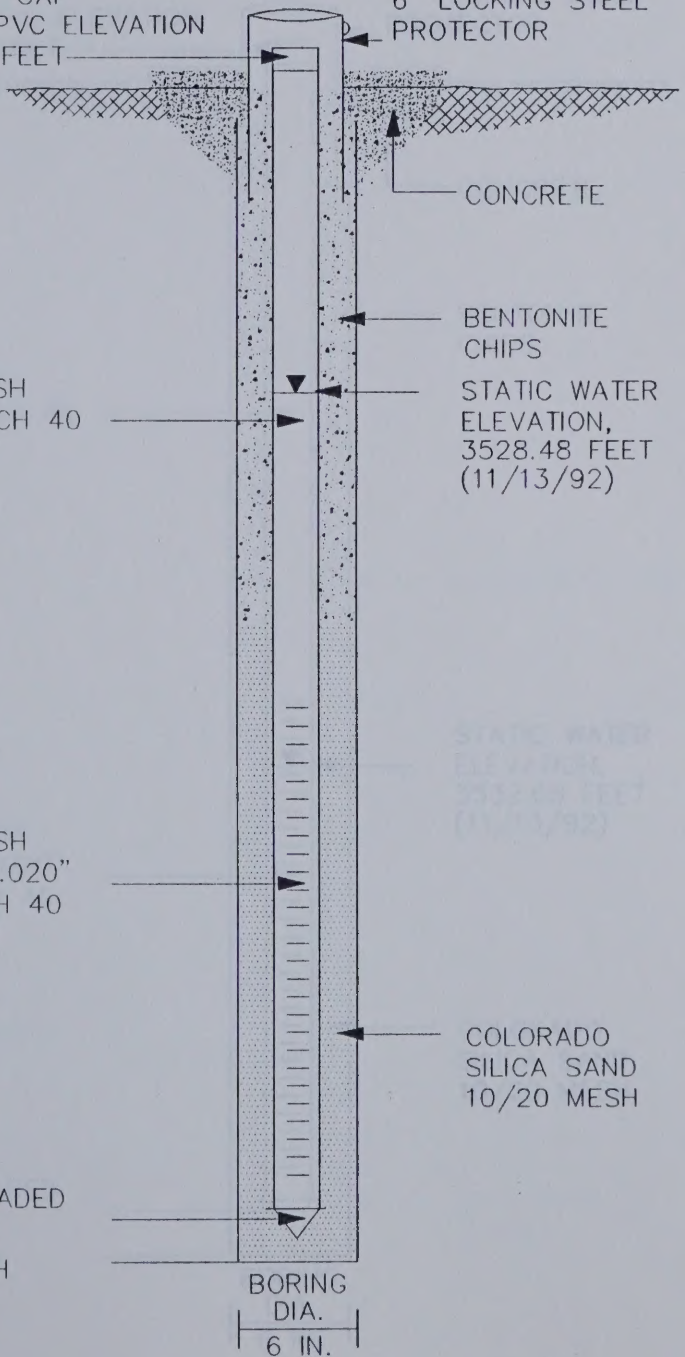
WELL COMPLETION LOGS

MONITORING WELL COMPLETION LOG

PROJECT 112035
SITE LAUREL LANDFILL
LOCATION SEE MAP

HYDROGEOLOGIST CURT COOVER
DRILLER PRO PUMP
DATE OCTOBER 27, 1992

HOLE I.D.
MW-1



PVC SLIP CAP
TOP OF PVC ELEVATION
3533.79 FEET

6" LOCKING STEEL PROTECTOR

DEPTH (FEET)			DEPTH (FEET)
		CONCRETE	+0.5 TO 3
		BENTONITE CHIPS	3 TO 14
+2 TO 15	2-INCH FLUSH THREADED SCH 40 PVC CASING	STATIC WATER ELEVATION, 3528.48 FEET (11/13/92)	
15 TO 20	2-INCH FLUSH THREADED 0.020" SLOTTED SCH 40 PVC SCREEN	COLORADO SILICA SAND 10/20 MESH	14 TO 20
	FLUSH THREADED SAND POINT		
20	TOTAL DEPTH		

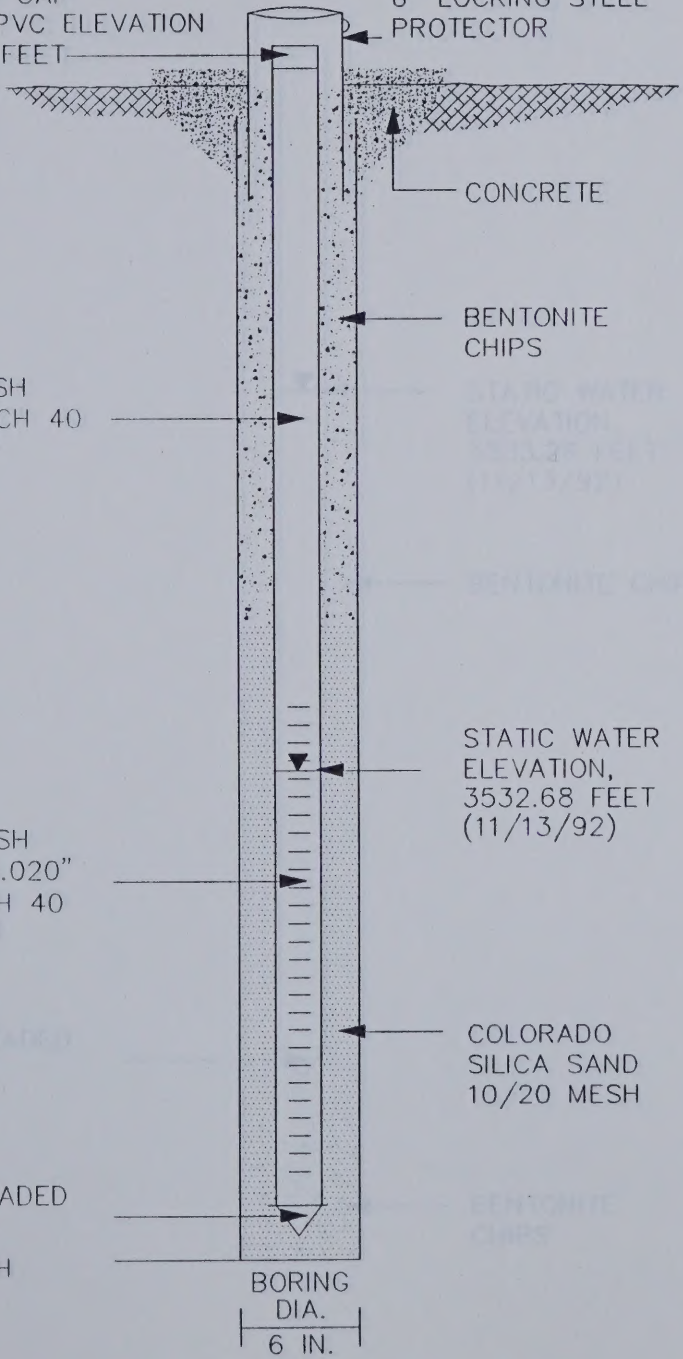
GEO RESEARCH

MONITORING WELL COMPLETION LOG

PROJECT 112035
SITE LAUREL LANDFILL
LOCATION SEE MAP

HYDROGEOLOGIST CURT COOVER
DRILLER PRO PUMP
DATE OCTOBER 27, 1992

HOLE I.D.
MW-2



DEPTH (FEET)	
	PVC SLIP CAP TOP OF PVC ELEVATION 3550.94 FEET
+2 TO 15	2-INCH FLUSH THREADED SCH 40 PVC CASING
15 TO 20	2-INCH FLUSH THREADED 0.020" SLOTTED SCH 40 PVC SCREEN
	FLUSH THREADED SAND POINT
20	TOTAL DEPTH

	DEPTH (FEET)
6" LOCKING STEEL PROTECTOR	
CONCRETE	+0.5 TO 3
BENTONITE CHIPS	3 TO 14
STATIC WATER ELEVATION, 3532.68 FEET (11/13/92)	
COLORADO SILICA SAND 10/20 MESH	14 TO 20

GEO RESEARCH

MONITORING WELL COMPLETION LOG

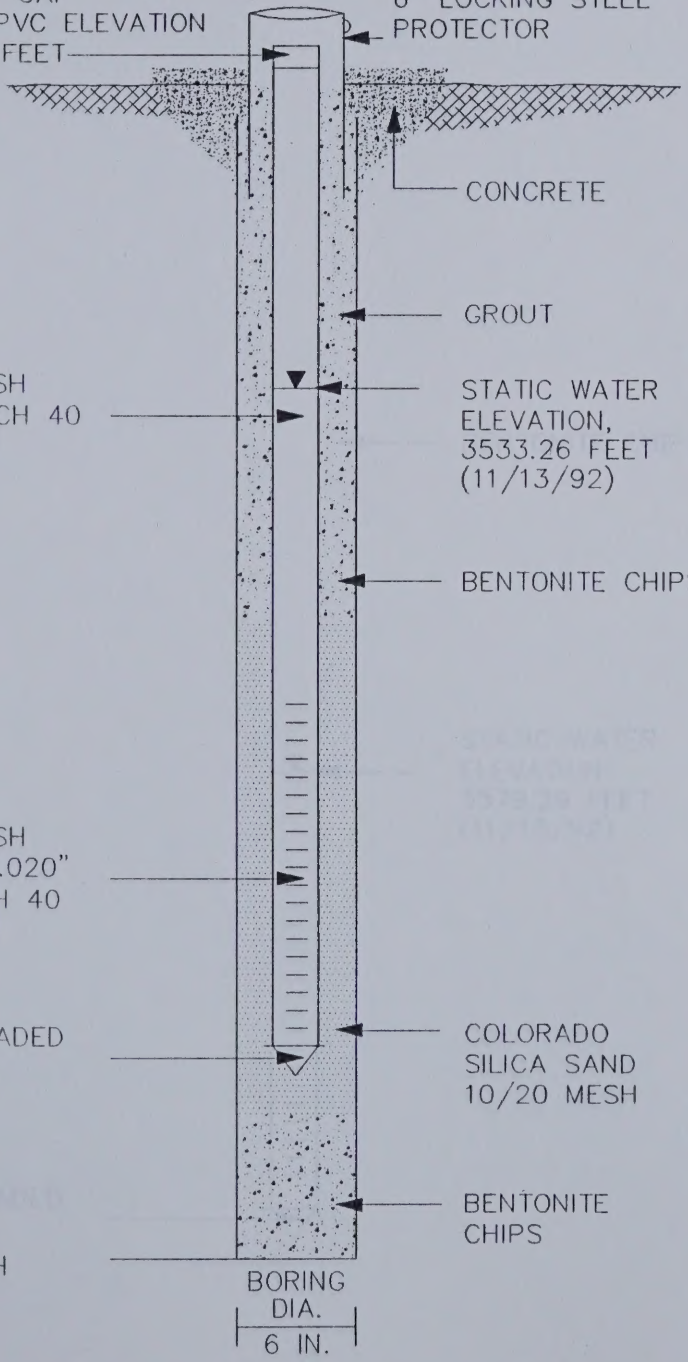
PROJECT 112035
SITE LAUREL LANDFILL
LOCATION SEE MAP

HYDROGEOLOGIST CURT COOVER
DRILLER PRO PUMP
DATE OCTOBER 28, 1992

HOLE I.D.
MW-3

PVC SLIP CAP
TOP OF PVC ELEVATION
3557.49 FEET

6" LOCKING STEEL PROTECTOR



DEPTH (FEET)	
+2 TO 36	2-INCH FLUSH THREADED SCH 40 PVC CASING
36 TO 41	2-INCH FLUSH THREADED 0.020" SLOTTED SCH 40 PVC SCREEN
	FLUSH THREADED SAND POINT
55	TOTAL DEPTH

	DEPTH (FEET)
CONCRETE	+0.5 TO 3
GROUT	3 TO 32
STATIC WATER ELEVATION, 3533.26 FEET (11/13/92)	
BENTONITE CHIPS	32 TO 35
COLORADO SILICA SAND 10/20 MESH	35 TO 42
BENTONITE CHIPS	42 TO 55

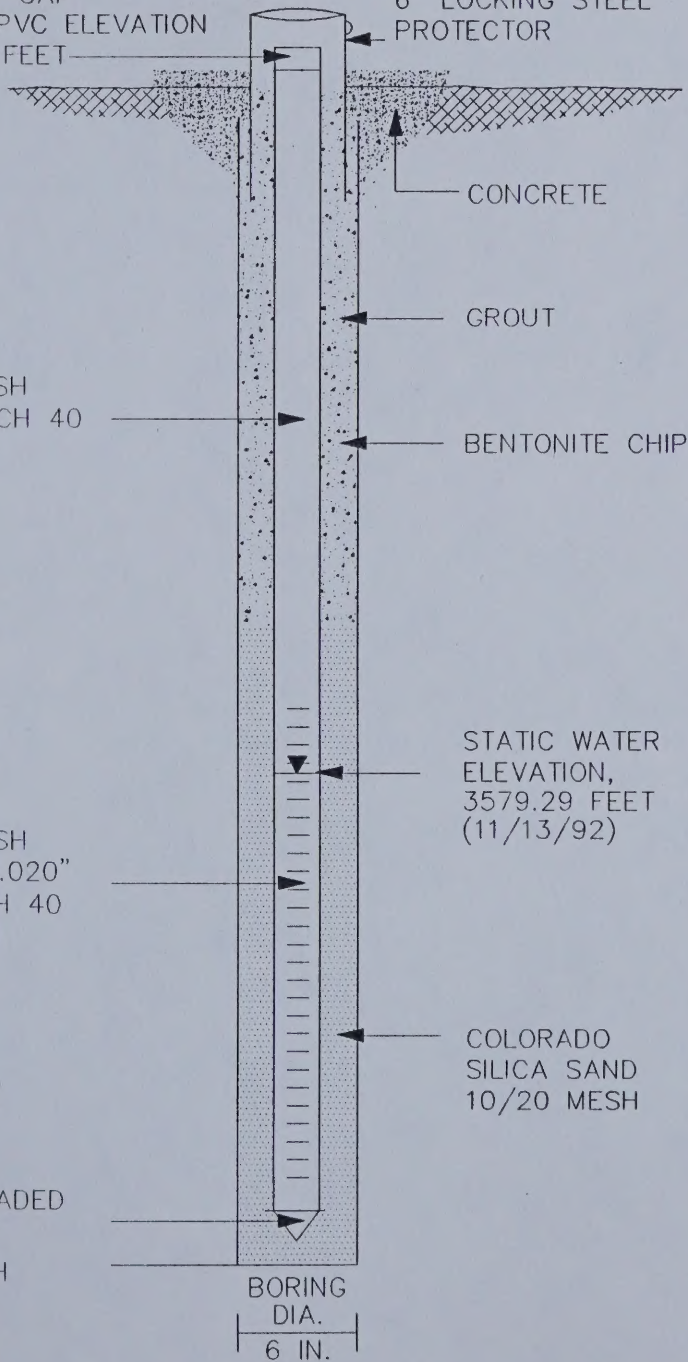
GEO RESEARCH

MONITORING WELL COMPLETION LOG

PROJECT 112035
SITE LAUREL LANDFILL
LOCATION SEE MAP

HYDROGEOLOGIST CURT COOVER
DRILLER PRO PUMP
DATE OCTOBER 28, 1992

HOLE I.D.
MW-4



DEPTH (FEET)	
	PVC SLIP CAP TOP OF PVC ELEVATION 3607.00 FEET
+2 TO 27	2-INCH FLUSH THREADED SCH 40 PVC CASING
27 TO 32	2-INCH FLUSH THREADED 0.020" SLOTTED SCH 40 PVC SCREEN
	FLUSH THREADED SAND POINT
32	TOTAL DEPTH

	DEPTH (FEET)
6" LOCKING STEEL PROTECTOR	
CONCRETE	+0.5 TO 3
GROUT	3 TO 23
BENTONITE CHIPS	23 TO 26
STATIC WATER ELEVATION, 3579.29 FEET (11/13/92)	
COLORADO SILICA SAND 10/20 MESH	26 TO 32

GEO RESEARCH

APPENDIX D

DHES COMPLETION LOGS OF WELLS

State of Montana
Department of Health
and Environmental Sciences

Route to: Solid Waste ☐

MONITORING WELL CONSTRUCTION

Facility/Project Name: City of Laurel Landfill
Local Grid Location of Well: ______ ft ☐ N ☐ S ______ ft ☐ E ☐ W
Well Name: MW-1

Facility License: 203
Grid Origin Location: Lat. ______ Long. ______ or
MT Unique Well Number: DHES Well Name:

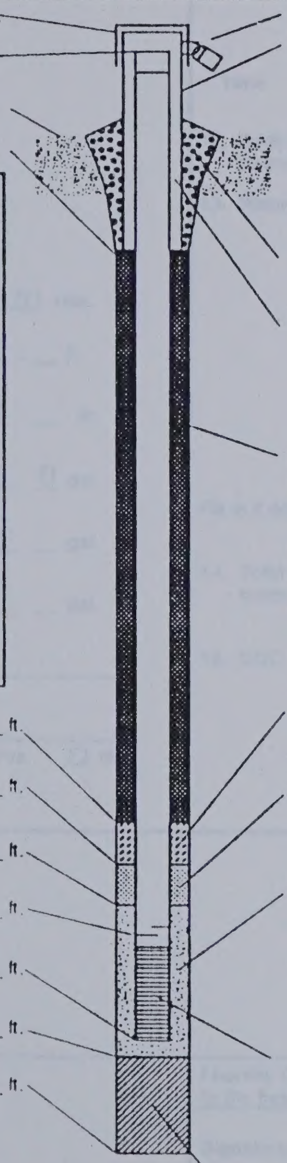
Type of Well: Water Table Observation Well ☐ 11 Piezometer ☒ 12
St. Plane ______ ft N ______ ft S
Date Well Installed: 10/24/92 (mm dd yy)

Section Location of Waste/Source: NW/4 Sec 33 T1S R24E ☐ E ☐ W

Distance Well Is From Waste/Source Boundary: 0 ft
Well Installed By: (Person's Name and Firm) Curt Coover, GeoResearch, Inc.

Location of Well Relative to Waste/Source: u ☐ Upgradient s ☐ Sidegradient d ☒ Downgradient n ☐ Not Known

Is Well a Point of Standards Application? ☒ Yes ☐ No
Monitoring Well Constructor License Number: MWC-177



A. Protective pipe, top elevation +2.7 ft. ~~MSL~~
B. Well casing, top elevation 3533.79 ft. MSL
C. Land Surface elevation ______ ft. MSL
D. Surface seal, bottom ______ ft. MSL or 3 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ GW ☐ SP ☐
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☒
13. Sieve analysis attached? ☐ Yes ☒ No
14. Drilling method used: Rotary ☒ Hollow Stem Auger ☐ Other ☐
15. Drilling fluid used: Water ☐ Air ☒ Drilling Mud ☐ None ☐
16. Drilling additives used? ☐ Yes ☒ No
Describe ______
17. Source of water: N/A

E. Bentonite seal, top ______ ft. MSL or 3 ft.
F. Fine sand, top ______ ft. MSL or - ft.
G. Filter pack, top ______ ft. MSL or 14 ft.
H. Screen joint, top ______ ft. MSL or 15 ft.
I. Well bottom ______ ft. MSL or 20 ft.
J. Filter pack, bottom ______ ft. MSL or 20 ft.
K. Borehole bottom ______ ft. MSL or 20 ft.
L. Borehole, diameter 6 in.
M. O.D. well casing 2.4 in.
N. I.D. well casing 2.0 in.

1. Cap and lock? ☒ Yes ☐ No
2. Protective cover pipe:
a. Inside diameter: 6.0 in.
b. Length: 5.0 ft.
c. Material: Steel ☒ Other ☐
d. Additional protection? ☐ Yes ☒ No
If yes, describe: ______
3. Surface seal: Bentonite ☐ Concrete ☒ Other ☐
4. Material between well casing and protective pipe: Bentonite ☐ Annular space seal ☐ Concrete Other ☒
5. Annular space seal: a. Granular bentonite ☐
b. ______ Lbs/gal mud weight . . . Bentonite-sand slurry ☐
c. ______ Lbs/gal mud weight . . . Bentonite slurry ☐
d. ______ % bentonite . . . . Bentonite cement grout ☐
e. 0 Ft^3 volume added for any of the above
f. How installed: Tremie ☐ Tremie pumped ☐ Gravity ☐
6. Bentonite seal: a. Bentonite granules ☐
b. ☐ 1/4 in. ☐ 3/8 in. ☐ 1/2. Bentonite pellets ☐
c. 3/8 inch chips Other ☒
7. Fine sand material: Manufacturer, product name & mesh size
a. None
b. Volume added ______ ft^3
8. Filter pack material: Manufacturer, product name & mesh size
a. Colorado Silica Sand 10x20
b. Volume added 1 ft^3
9. Well casing: Flush threaded PVC schedule 40 ☒ Flush threaded PVC schedule 80 ☐ Other ☐
10. Screen material: Sch. 40 PVC
a. Screen type: Factory cut ☒ Continuous slot ☐ Other ☐
b. Manufacturer: ______
c. Slot size: 0.020 in.
d. Slotted length: 4.4 ft.
11. Backfill material: None ☒

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature:
Firm: GeoResearch, Inc.

State of Montana
Department of Health
and Environmental Sciences

Route to: Solid Waste ☐

MONITORING WELL DEVELOPMENT

Facility/Project Name: City of Laurel Landfill
County Name: Yellowstone
Well Name: MW-1
Facility License Number: 203
County Code: __
MT Unique Well Number: ______
DHES Well Number: ___
Well Installed By: (Person's Name and Firm) Curt Coover - GeoResearch, Inc.
Monitoring Well Constructor License Number: MWC - 177

1. Can this well be purged dry? ☐ Yes ☒ No

2. Well development method
   - surged with bailer and bailed ☒
   - surged with bailer and pumped ☐
   - surged with block and bailed ☐
   - surged with block and pumped ☐
   - surged with block, bailed and pumped ☐
   - compressed air ☐
   - bailed only ☐
   - pumped only ☐
   - pumped slowly ☐
   - Other ______ ☐

3. Time spent developing well 20 min.

4. Depth of well (from top of casing) 22. ft.

5. Inside diameter of well 2. in.

6. Volume of water in filter pack and well casing 5.0 gal.

7. Volume of water removed from well 15. gal.

8. Volume of water added (if any) -. gal.

9. Source of water added ______

10. Analysis performed on water added? (If yes, attach results) ☐ Yes ☐ No

	Before Development	After Development
11. Depth to Water (from top of well casing) a.	5.375 ft.	5.31 ft.
Date b.	10/27/92 (mm dd yy)	11/13/92 (mm dd yy)
Time c.	5:50 ☐ a.m. ☒ p.m.	10:46 ☒ a.m. ☐ p.m.
12. Sediment in well bottom	0. inches	0. inches
13. Water clarity	Clear ☐ Turbid ☒	Clear ☐ Turbid ☒
(Describe)	Muddy at First Last 10 Gal. Turbid	Slighty Turbid

Fill in if drilling fluids were used and well is at solid waste facility:

14. Total suspended solids	____._ mg/l	____._ mg/l
15. COD	____._ mg/l	____._ mg/l

16. Additional comments on development

Well developed by: (Person's Name and Firm)
Name: Curt Coover
Firm: GeoResearch, Inc.

I hereby certify that the above information is true and correct to the best of my knowledge
Signature:
Print Initials: C A C
Firm: GeoResearch, Inc.

Note: Shaded areas are for DHES use only. See instructions for more information including a list of county codes.

State of Montana
Department of Health
and Environmental Sciences

Route to: Solid Waste ☐

MONITORING WELL CONSTRUCTION

Facility/Project Name: City of Laurel Landfill

Local Grid Location of Well: ______ ft ☐ N ☐ S ______ ft ☐ E ☐ W

Well Name: MW-2

Facility License: 203

Grid Origin Location: Lat. ______ Long. ______ or

MT Unique Well Number: DHES Well Name:

Type of Well: Water Table Observation Well ☒ 11 Piezometer ☐ 12

St. Plane ______ ft N ______ ft S

Date Well Installed: 10/24/92 (mm dd yy)

Section Location of Waste/Source: NW/4 Sec 33 T1S R24E ☐ E ☐ W

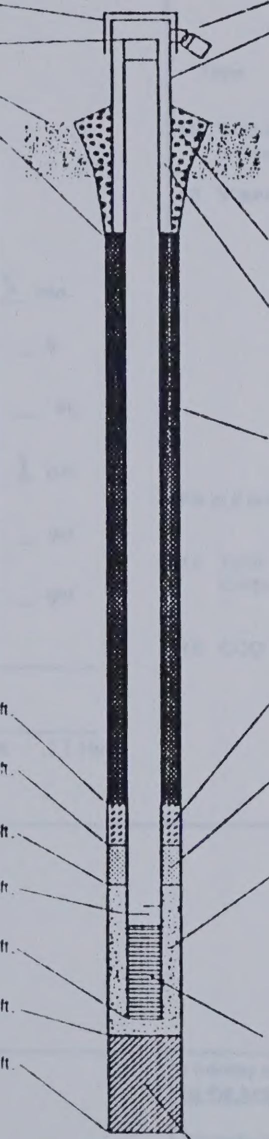
Distance Well Is From Waste/Source Boundary: 15 ft

Well Installed By: (Person's Name and Firm) Curt Coover, GeoResearch, Inc.

Location of Well Relative to Waste/Source: u ☐ Upgradient s ☐ Sidegradient d ☒ Downgradient n ☐ Not Known

Is Well a Point of Standards Application? ☒ Yes ☐ No

Monitoring Well Constructor License Number: MWC-177



A. Protective pipe, top elevation +2.7 ft. MSL
B. Well casing, top elevation 3550.94 ft. MSL
C. Land Surface elevation ____.__ ft. MSL
D. Surface seal, bottom ____.__ ft. MSL or 3. ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ GW ☐ SP ☐
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☒

13. Sieve analysis attached? ☐ Yes ☒ No

14. Drilling method used: Rotary ☒ Hollow Stem Auger ☐ Other ☐ ______

15. Drilling fluid used: Water ☐ Air ☒ Drilling Mud ☐ None ☐

16. Drilling additives used? ☐ Yes ☒ No

Describe ______

17. Source of water: N/A

E. Bentonite seal, top ____.__ ft. MSL or 3. ft.
F. Fine sand, top ____.__ ft. MSL or – ft.
G. Filter pack, top ____.__ ft. MSL or 14. ft.
H. Screen joint, top ____.__ ft. MSL or 15. ft.
I. Well bottom ____.__ ft. MSL or 20. ft.
J. Filter pack, bottom ____.__ ft. MSL or 20. ft.
K. Borehole bottom ____.__ ft. MSL or 20. ft.
L. Borehole, diameter 6. in.
M. O.D. well casing 2.4 in.
N. I.D. well casing 2.0 in.

1. Cap and lock? ☒ Yes ☐ No
2. Protective cover pipe:
a. Inside diameter: 6.0 in.
b. Length: 5.0 ft.
c. Material: Steel ☒ Other ☐ ______
d. Additional protection? ☐ Yes ☒ No
If yes, describe: ______
3. Surface seal: Bentonite ☐ Concrete ☒ Other ☐ ______
4. Material between well casing and protective pipe: Bentonite ☐ Annular space seal ☐ Other ☒ Concrete
5. Annular space seal: a. Granular bentonite ☐
b. ______ Lbs/gal mud weight . . . Bentonite-sand slurry ☐
c. ______ Lbs/gal mud weight . . . Bentonite slurry ☐
d. ______ % bentonite . . . . Bentonite cement grout ☐
e. None Ft^3 volume added for any of the above
f. How installed: Tremie ☐ Tremie pumped ☐ Gravity ☐
6. Bentonite seal: a. Bentonite granules ☐
b. ☐ 1/4 in. ☐ 3/8 in. ☐ 1/2. Bentonite pellets ☐
c. 3/8 inch chips Other ☒
7. Fine sand material: Manufacturer, product name & mesh size
a. None
b. Volume added ______ ft^3
8. Filter pack material: Manufacturer, product name & mesh size
a. Colorado Silica Sand 10x20
b. Volume added 1 ft^3
9. Well casing: Flush threaded PVC schedule 40 ☒ Flush threaded PVC schedule 80 ☐ Other ☐ ______
10. Screen material: Sch. 40 PVC
a. Screen type: Factory cut ☒ Continuous slot ☐ Other ☐ ______
b. Manufacturer: ______
c. Slot size: 0.020 in.
d. Slotted length: 4.4 ft.
11. Backfill material: ______ None ☒

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature:

Firm: GeoResearch, Inc.

State of Montana
Department of Health
and Environmental Sciences

Route to: Solid Waste ☐

MONITORING WELL DEVELOPMENT

Facility/Project Name: City of Laurel Landfill

County Name: Yellowstone

Well Name: MW-2

Facility License Number: 203

County Code:

MT Unique Well Number:

DHES Well Number:

Well Installed By: (Person's Name and Firm): Curt Coover - GeoResearch, Inc.

Monitoring Well Constructor License Number: MWC - 177

1. Can this well be purged dry? ☒ Yes ☐ No

2. Well development method
   - surged with bailer and bailed ☒
   - surged with bailer and pumped ☐
   - surged with block and bailed ☐
   - surged with block and pumped ☐
   - surged with block, bailed and pumped ☐
   - compressed air ☐
   - bailed only ☐
   - pumped only ☐
   - pumped slowly ☐
   - Other ☐

3. Time spent developing well: 15 min.

4. Depth of well (from top of casing): 22. ft.

5. Inside diameter of well: 2. in.

6. Volume of water in filter pack and well casing: 2.1 gal.

7. Volume of water removed from well: 3. gal.

8. Volume of water added (if any): - gal.

9. Source of water added:

10. Analysis performed on water added? ☐ Yes ☐ No
(If yes, attach results)

		Before Development	After Development
11. Depth to Water (from top of well casing)	a.	18.17 ft.	18.26 ft.
Date	b.	10/27/92 (mm dd yy)	11/13/92 (mm dd yy)
Time	c.	6:10 ☐ a.m. ☒ p.m.	10:41 ☒ a.m. ☐ p.m.
12. Sediment in well bottom		0. inches	0. inches
13. Water clarity		Clear ☐ Turbid ☒ (Describe) Muddy	Clear ☐ Turbid ☒ (Describe) Somewhat Turbid

Fill in if drilling fluids were used and well is at solid waste facility:

	Before Development	After Development
14. Total suspended solids	mg/l	mg/l
15. COD	mg/l	mg/l

16. Additional comments on development

Well developed by: (Person's Name and Firm)

Name: Curt Coover

Firm: GeoResearch, Inc.

I hereby certify that the above information is true and correct to the best of my knowledge

Signature: Curt Coover

Print Initials: C A C

Firm: GeoResearch, Inc.

Note: Shaded areas are for DHES use only. See instructions for more information including a list of county codes.

State of Montana
Department of Health
and Environmental Sciences

Route to: Solid Waste ☐

MONITORING WELL CONSTRUCTION

Facility/Project Name: City of Laurel Landfill

Facility License: 203

Type of Well: Water Table Observation Well ☐ 11 Piezometer ☒ 12

Distance Well Is From Waste/Source Boundary: 10 ft

Is Well a Point of Standards Application? ☒ Yes ☐ No

Local Grid Location of Well: ______ ft ☐ N ☐ S ______ ft ☐ E ☐ W

Grid Origin Location: Lat. ______ Long. ______ or St. Plane ______ ft N ______ ft S

Section Location of Waste/Source: NW/4 Sec 33 T1S R24E ☐ E ☐ W

Location of Well Relative to Waste/Source: u ☐ Upgradient s ☐ Sidegradient d ☒ Downgradient n ☐ Not Known

Well Name: MW-3

MT Unique Well Number / DHES Well Name: [redacted]

Date Well Installed: 10/24/92 (mm dd yy)

Well Installed By: (Person's Name and Firm) Curt Coover, GeoResearch, Inc.

Monitoring Well Constructor License Number: MWC-177 [redacted]

A. Protective pipe, top elevation: +2.7 ft. MSL

B. Well casing, top elevation: 3557.49 ft. MSL

C. Land Surface elevation: ____ ft. MSL

D. Surface seal, bottom: ____ ft. MSL or 3 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ GW ☐ SP ☐
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☒

13. Sieve analysis attached? ☐ Yes ☒ No

14. Drilling method used: Rotary ☒ Hollow Stem Auger ☐ Other ☐

15. Drilling fluid used: Water ☐ Air ☒ Drilling Mud ☐ None ☐

16. Drilling additives used? ☐ Yes ☒ No

Describe ______

17. Source of water: N/A

E. Bentonite seal, top: ____ ft. MSL or 32 ft.

F. Fine sand, top: ____ ft. MSL or – ft.

G. Filter pack, top: ____ ft. MSL or 35 ft.

H. Screen joint, top: ____ ft. MSL or 36 ft.

I. Well bottom: ____ ft. MSL or 41 ft.

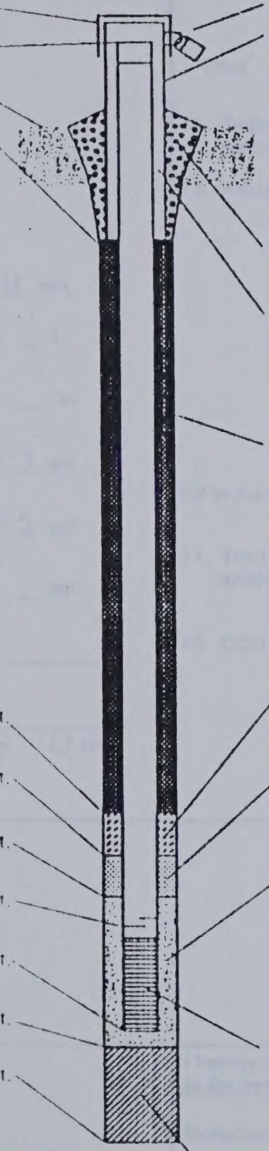
J. Filter pack, bottom: ____ ft. MSL or 42 ft.

K. Borehole bottom: ____ ft. MSL or 55 ft.

L. Borehole, diameter: 6 in.

M. O.D. well casing: 2.4 in.

N. I.D. well casing: 2.0 in.



1. Cap and lock? ☒ Yes ☐ No
2. Protective cover pipe:
   a. Inside diameter: 6.0 in.
   b. Length: 5.0 ft.
   c. Material: Steel ☒ Other ☐
   d. Additional protection? ☐ Yes ☒ No
   If yes, describe: ______
3. Surface seal: Bentonite ☐ Concrete ☒ Other ☐
4. Material between well casing and protective pipe: Bentonite ☐ Annular space seal ☐ Concrete Other ☒
5. Annular space seal: a. Granular bentonite ☐
   b. ____ Lbs/gal mud weight . . . Bentonite-sand slurry ☐
   c. ____ Lbs/gal mud weight . . . Bentonite slurry ☐
   d. 3 % bentonite . . . . Bentonite cement grout ☒
   e. 5 Ft^3 volume added for any of the above
   f. How installed: Tremie ☐ Tremie pumped ☒ Gravity ☐
6. Bentonite seal: a. Bentonite granules ☐
   b. ☐ 1/4 in. ☐ 3/8 in. ☐ 1/2. Bentonite pellets ☐
   c. 3/8 inch chips Other ☒
7. Fine sand material: Manufacturer, product name & mesh size
   a. None
   b. Volume added ______ ft^3
8. Filter pack material: Manufacturer, product name & mesh size
   a. Colorado Silica Sand 10x20
   b. Volume added 1.1 ft^3
9. Well casing: Flush threaded PVC schedule 40 ☒ Flush threaded PVC schedule 80 ☐ Other ☐
10. Screen material: Sch. 40 PVC
   a. Screen type: Factory cut ☒ Continuous slot ☐ Other ☐
   b. Manufacturer: ______
   c. Slot size: 0020 in.
   d. Slotted length: 4.4 ft.
11. Backfill material: 3/8 inch Bentonite Chips None ☐

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Curt Coover

Firm: GeoResearch, Inc.

State of Montana
Department of Health
and Environmental Sciences

Route to: Solid Waste ☐

MONITORING WELL DEVELOPMENT

Facility/Project Name: City of Laurel Landfill

County Name: Yellowstone

Well Name: MW-3

Facility License Number: 203

County Code:

MT Unique Well Number:

DHES Well Number:

Well Installed By: (Person's Name and Firm) Curt Coover - GeoResearch, Inc.

Monitoring Well Constructor License Number: MWC - 177

1. Can this well be purged dry? ☒ Yes ☐ No

2. Well development method
- surged with bailer and bailed ☒
- surged with bailer and pumped ☐
- surged with block and bailed ☐
- surged with block and pumped ☐
- surged with block, bailed and pumped ☐
- compressed air ☐
- bailed only ☐
- pumped only ☐
- pumped slowly ☐
- Other ________ ☐

3. Time spent developing well: 10 min.

4. Depth of well (from top of casing): 44 ft.

5. Inside diameter of well: 2 in.

6. Volume of water in filter pack and well casing: 4.3 gal.

7. Volume of water removed from well: 3.5 gal.

8. Volume of water added (if any): – gal.

9. Source of water added: ________

10. Analysis performed on water added? ☐ Yes ☐ No
(If yes, attach results)

	Before Development	After Development
11. Depth to Water (from top of well casing)	a. 33.31 ft.	24.23 ft.
Date	b. 10/27/92 (mm dd yy)	11/13/92 (mm dd yy)
Time	c. 5:40 ☐ a.m. ☒ p.m.	10:36 ☒ a.m. ☐ p.m.
12. Sediment in well bottom	0. inches	0. inches
13. Water clarity	Clear ☐ Turbid ☒ (Describe) Muddy	Clear ☐ Turbid ☒ (Describe) Somewhat Turbid

Fill in if drilling fluids were used and well is at solid waste facility:

14. Total suspended solids	____ mg/l	____ mg/l
15. COD	____ mg/l	____ mg/l

16. Additional comments on development

Well developed by: (Person's Name and Firm)

Name: Curt Coover

Firm: GeoResearch, Inc.

I hereby certify that the above information is true and correct to the best of my knowledge

Signature:

Print Initials: C A C

Firm: GeoResearch, Inc.

Note: Shaded areas are for DHES use only. See instructions for more information including a list of county codes.

State of Montana
Department of Health
and Environmental Sciences

Route to: Solid Waste ☐

MONITORING WELL CONSTRUCTION

Facility/Project Name City of Laurel Landfill	Local Grid Location of Well ______ ft ☐N ☐S ______ ft ☐E ☐W	Well Name MW-4
Facility License 203	Grid Origin Location Lat. ______ Long. ______ or St. Plane ______ ft N ______ ft S	MT Unique Well Number [redacted] DHES Well Name
Type of Well: Water Table Observation Well ☒ 11 Piezometer ☐ 12	Section Location of Waste/Source NW/4 Sec 33 T1S R24E ☐E ☐W	Date Well Installed 10/24/92 (mm dd yy)
Distance Well Is From Waste/Source Boundary ______ ft	Location of Well Relative to Waste/Source u ☒ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known	Well Installed By: (Person's Name and Firm) Curt Coover, GeoResearch, Inc.
Is Well a Point of Standards Application? ☒ Yes ☐ No		Monitoring Well Constructor License Number MWC-177 [redacted]

A. Protective pipe, top elevation +2.7 ft. MSL

B. Well casing, top elevation 3607.00 ft. MSL

C. Land Surface elevation ______ ft. MSL

D. Surface seal, bottom ______ ft. MSL or 3 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ GW ☐ SP ☐
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☒

13. Sieve analysis attached? ☐ Yes ☒ No

14. Drilling method used: Rotary ☒
Hollow Stem Auger ☐
Other ☐

15. Drilling fluid used: Water ☐ Air ☒
Drilling Mud ☐ None ☐

16. Drilling additives used? ☐ Yes ☒ No

Describe ______

17. Source of water:
N/A

E. Bentonite seal, top ______ ft. MSL or 23 ft.

F. Fine sand, top ______ ft. MSL or – ft.

G. Filter pack, top ______ ft. MSL or 26 ft.

H. Screen joint, top ______ ft. MSL or 27 ft.

I. Well bottom ______ ft. MSL or 32 ft.

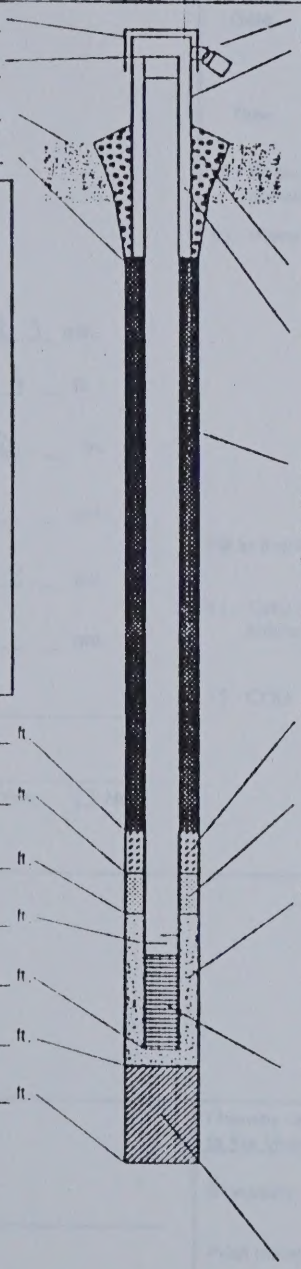
J. Filter pack, bottom ______ ft. MSL or 32 ft.

K. Borehole bottom ______ ft. MSL or 32 ft.

L. Borehole, diameter 6 in.

M. O.D. well casing 2.4 in.

N. I.D. well casing 2.0 in.



1. Cap and lock? ☒ Yes ☐ No

2. Protective cover pipe:
a. Inside diameter: 6.0 in.
b. Length: 5.0 ft.
c. Material: Steel ☒
Other ☐
d. Additional protection? ☐ Yes ☒ No
If yes, describe: ______

3. Surface seal: Bentonite ☐
Concrete ☒
Other ☐

4. Material between well casing and protective pipe:
Bentonite ☐
Annular space seal ☐
Concrete Other ☒

5. Annular space seal: a. Granular bentonite ☐
b. ______ Lbs/gal mud weight . . . Bentonite-sand slurry ☐
c. ______ Lbs/gal mud weight . . . Bentonite slurry ☐
d. 3 % bentonite . . . . Bentonite cement grout ☒
e. 3.2 Ft^3 volume added for any of the above
f. How installed: Tremie ☐
Tremie pumped ☒
Gravity ☐

6. Bentonite seal: a. Bentonite granules ☐
b. ☐ 1/4 in. ☐ 3/8 in. ☐ 1/2. Bentonite pellets ☐
c. 3/8 inch chips Other ☒

7. Fine sand material: Manufacturer, product name & mesh size
a. None
b. Volume added ______ ft^3

8. Filter pack material: Manufacturer, product name & mesh size
a. Colorado Silica Sand 10x20
b. Volume added 1 ft^3

9. Well casing: Flush threaded PVC schedule 40 ☒
Flush threaded PVC schedule 80 ☐
Other ☐

10. Screen material: Sch. 40 PVC
a. Screen type: Factory cut ☒
Continuous slot ☐
Other ☐
b. Manufacturer: ______
c. Slot size: 0.020 in.
d. Slotted length: 4.4 ft.

11. Backfill material: None ☒

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature Curt Coover

Firm GeoResearch, Inc.

State of Montana
Department of Health
and Environmental Sciences

Route to: Solid Waste ☐

MONITORING WELL DEVELOPMENT

Facility/Project Name: City of Laurel Landfill
County Name: Yellowstone
Well Name: MW-4
Facility License Number: 203
County Code:
MT Unique Well Number:
DHES Well Number:
Well Installed By: (Person's Name and Firm) Curt Coover - GeoResearch, Inc.
Monitoring Well Constructor License Number: MWC - 177

1. Can this well be purged dry? ☒ Yes ☐ No

2. Well development method
   - surged with bailer and bailed ☒
   - surged with bailer and pumped ☐
   - surged with block and bailed ☐
   - surged with block and pumped ☐
   - surged with block, bailed and pumped ☐
   - compressed air ☐
   - bailed only ☐
   - pumped only ☐
   - pumped slowly ☐
   - Other ______ ☐

3. Time spent developing well 13 min.

4. Depth of well (from top of casing) 34. ft.

5. Inside diameter of well 2. in.

6. Volume of water in filter pack and well casing ____ gal.

7. Volume of water removed from well 2. gal.

8. Volume of water added (if any) -. gal.

9. Source of water added ______

10. Analysis performed on water added? ☐ Yes ☐ No
(If yes, attach results)

	Before Development	After Development
11. Depth to Water (from top of well casing) a.	27.79 ft.	27.71 ft.
Date b.	10/27/92 (mm dd yy)	11/13/92 (mm dd yy)
Time c.	5:27 ☐ a.m. ☒ p.m.	10:25 ☒ a.m. ☐ p.m.
12. Sediment in well bottom	0 inches	0. inches
13. Water clarity	Clear ☐ Turbid ☒	Clear ☐ Turbid ☒
(Describe)	Muddy	Somewhat Turbid

Fill in if drilling fluids were used and well is at solid waste facility:

14. Total suspended solids	____ mg/l	____ mg/l
15. COD	____ mg/l	____ mg/l

16. Additional comments on development

Well developed by: (Person's Name and Firm)

Name: Curt Coover

Firm: GeoResearch, Inc.

I hereby certify that the above information is true and correct to the best of my knowledge

Signature:

Print Initials: C A C

Firm: GeoResearch, Inc.

Note: Shaded areas are for DHES use only. See instructions for more information including a list of county codes.

APPENDIX E

SOIL LABORATORY REPORTS

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: Curt Coover
ADDRESS: GeoResearch, Inc.
P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-50499
DATE: 12/10/92 da

SOIL ANALYSIS

112035 Laurel Landfill
Sampled 10/27/92
Submitted 12/03/92
Analyzed 12/09/92

pH	7.8	s.u.
Total Organic Carbon	0.5	% by weight

Chen-Northern, Inc.

A member of the HIH group of companies

1610 B STREET
P. O. BOX 4699
HELENA, MT 59604
(406) 443-5210
FAX (406) 449-3729

TECHNICAL REPORT

AMERICAN COUNCIL OF INDEPENDENT LABORATORIES, INC.

REPORT TO: GEO Research
Attn: Ms. Sally Staley
P.O. Box 5597
Helena, MT 59604

DATE: December 8, 1992
JOB NUMBER: 89-90
SHEET: 1 **OF** 1
INVOICE NO.: 127396

REPORT OF: Laboratory Analysis of Soil for Laurel Landfill; Project No. 112035

SAMPLE IDENTIFICATION:

On December 2, 1992 your personnel delivered to our laboratory one soil sample reported to be from the above referenced project. At your request, we performed particle size analysis and moisture content tests in accordance with ASTM D422 and D1140 and D2216, respectively.

The test results are summarized as follows:

TEST RESULTS

SIEVE ANALYSIS	Sample: R-1; 6'-7' Lab No. 11483
Sieve Size	PERCENT PASSING
No. 4	100
No. 10	100
No. 20	99
No. 40	98
No. 80	96
No. 200	92
HYDROMETER ANALYSIS	
0.05 mm	*
0.037 mm	*
0.0225 mm	79
0.019 mm	76
0.012 mm	70
0.009 mm	67
0.005 mm	59
0.002 mm	33
MOSISTURE CONTENT	
As Received, %	16.0

* The soil/slurry did not register on the hydrometer scale, no readings were obtained

Reviewed By: Jeremiah B. Bowser

Distribution:

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Chen-Northern, Inc.

GRAIN SIZE DISTRIBUTION CURVE

Project: Geo Research

Location: L-2

Classification Lean CLAY

Moisture Content ______ %

Sample No. 1001

Job No. 91-627

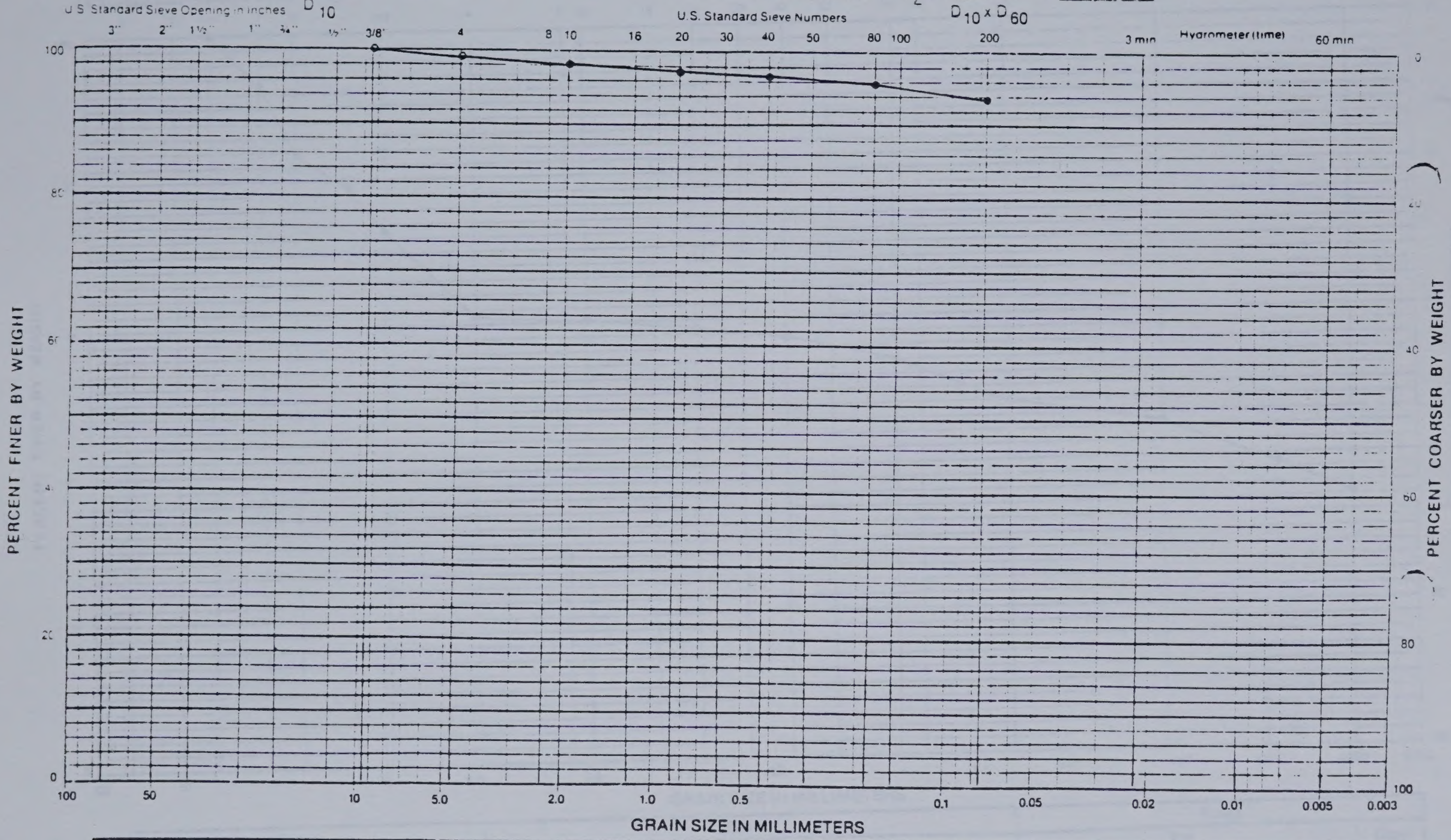
Date March, 1992

Liquid Limit 43 %

Plasticity Index 24 %

Coefficient of Uniformity = $C_U = \frac{D_{60}}{D_{10}}$ = N/A

Coefficient of Curvature = $C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ = N/A



Gravel		Sand			Fines	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

(Rev. 1/89) CNI-105

GRAIN SIZE DISTRIBUTION CURVE

Project: Geo Research

Location: L-1

Classification Clayey GRAVEL

Moisture Content ______ %

Sample No. 1000

Job No. 91-627

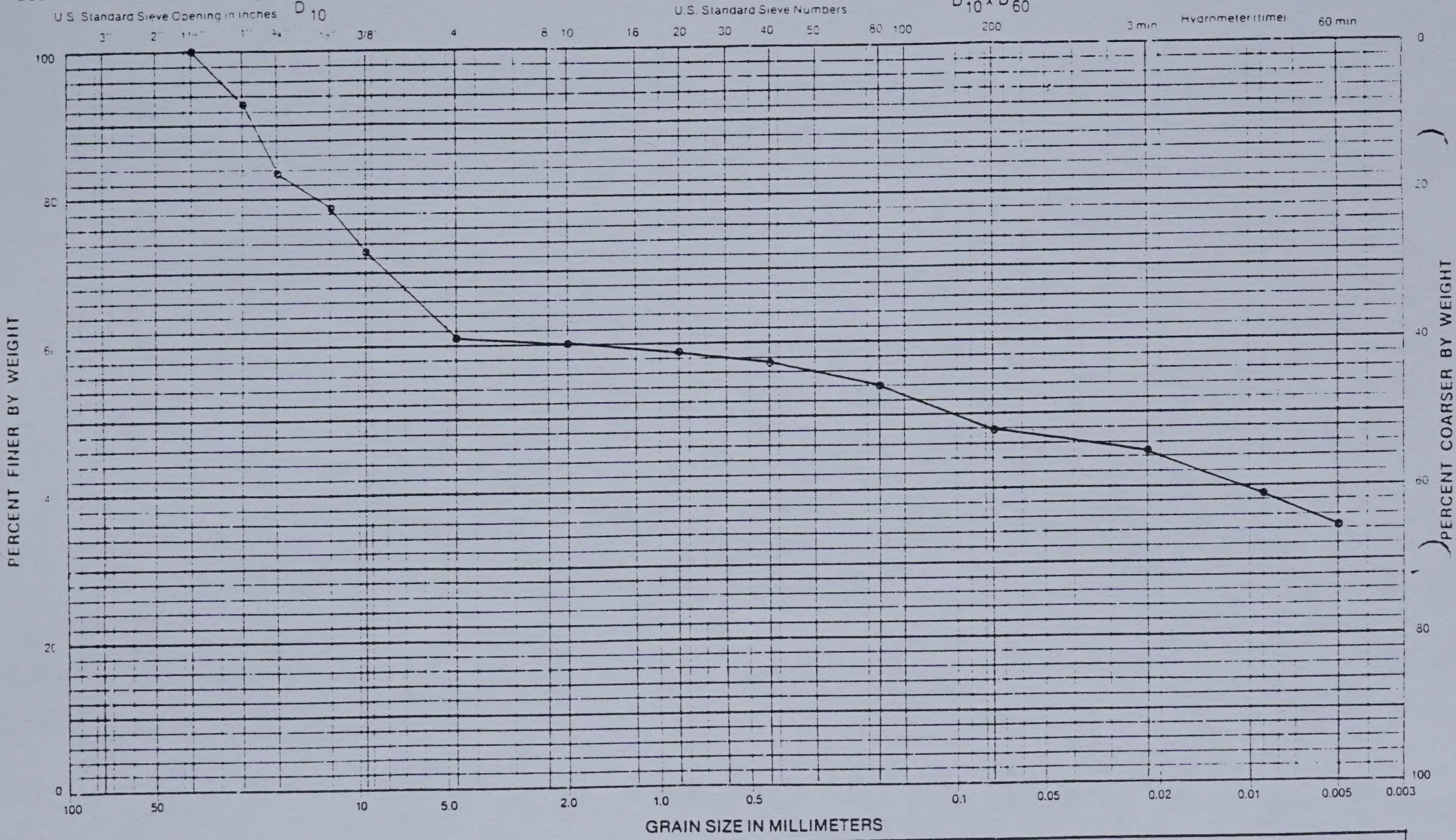
Date March, 1992

Liquid Limit 53 %

Plasticity Index 23 %

Coefficient of Uniformity $= C_U = \frac{D_{60}}{D_{10}}$ = N/A

Coefficient of Curvature $= C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ = N/A

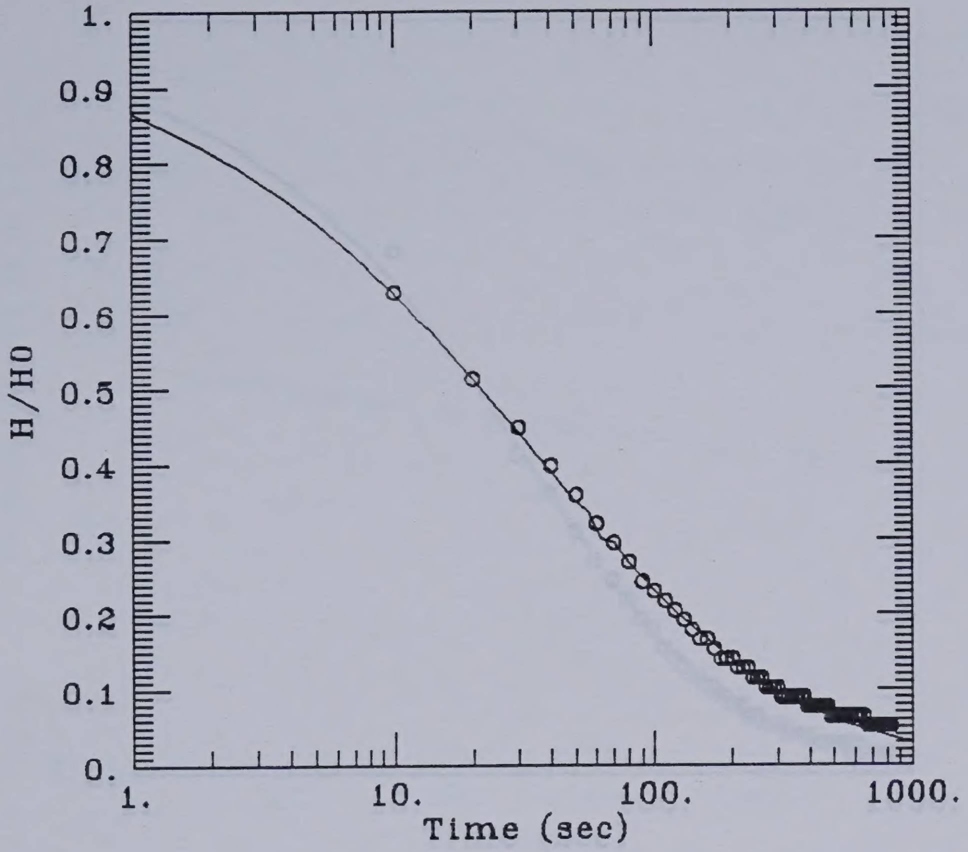


Gravel		Sand			Fines	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

(Rev. 1/89) CNI-105

APPENDIX F

SLUG TESTING CURVES



DATA SET:
lmw-1in.dat
12/29/92

AQUIFER TYPE:
Confined
SOLUTION METHOD:
Cooper et al.

ESTIMATED PARAMETERS:
$T = 6.0755E-05\ ft^2/sec$
$S = 0.05021$

TEST DATA:
H0 = 1.8 ft
rc = 0.08333 ft
rw = 0.25 ft

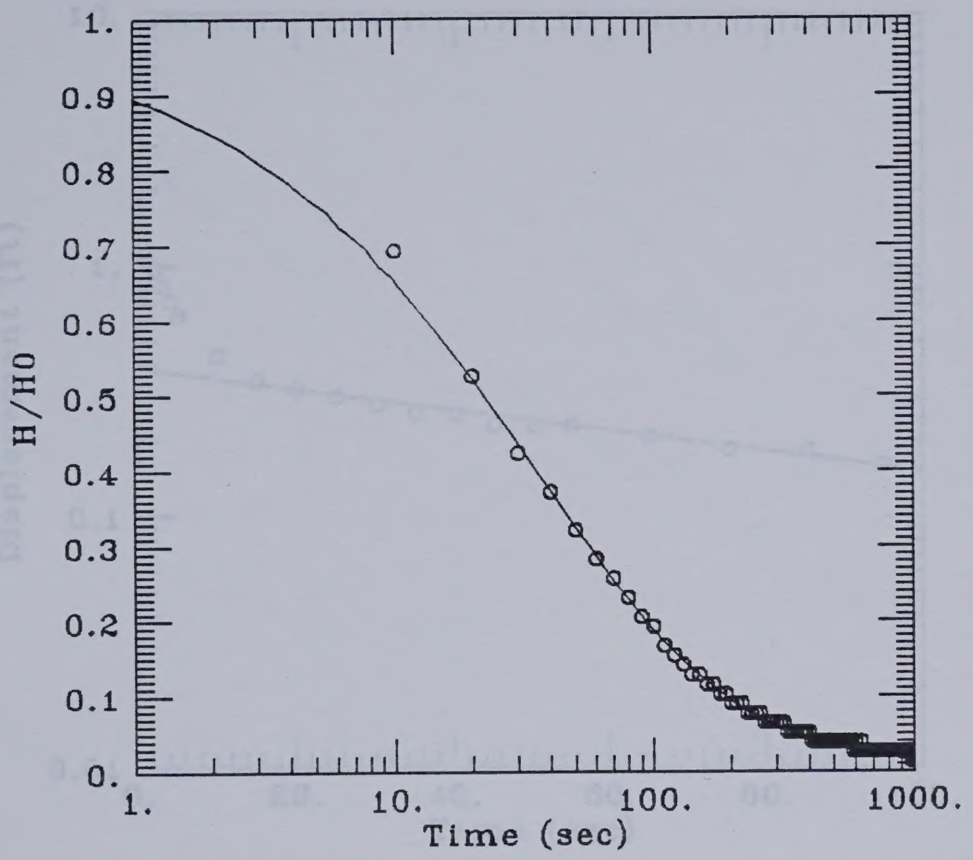
MW-1 Slug In

GeoResearch, Inc.

Client: **City of Laurel**

Project No.: **112035**

Location: **Laurel Landfill**



DATA SET:
lmw-1out.dat
12/29/92

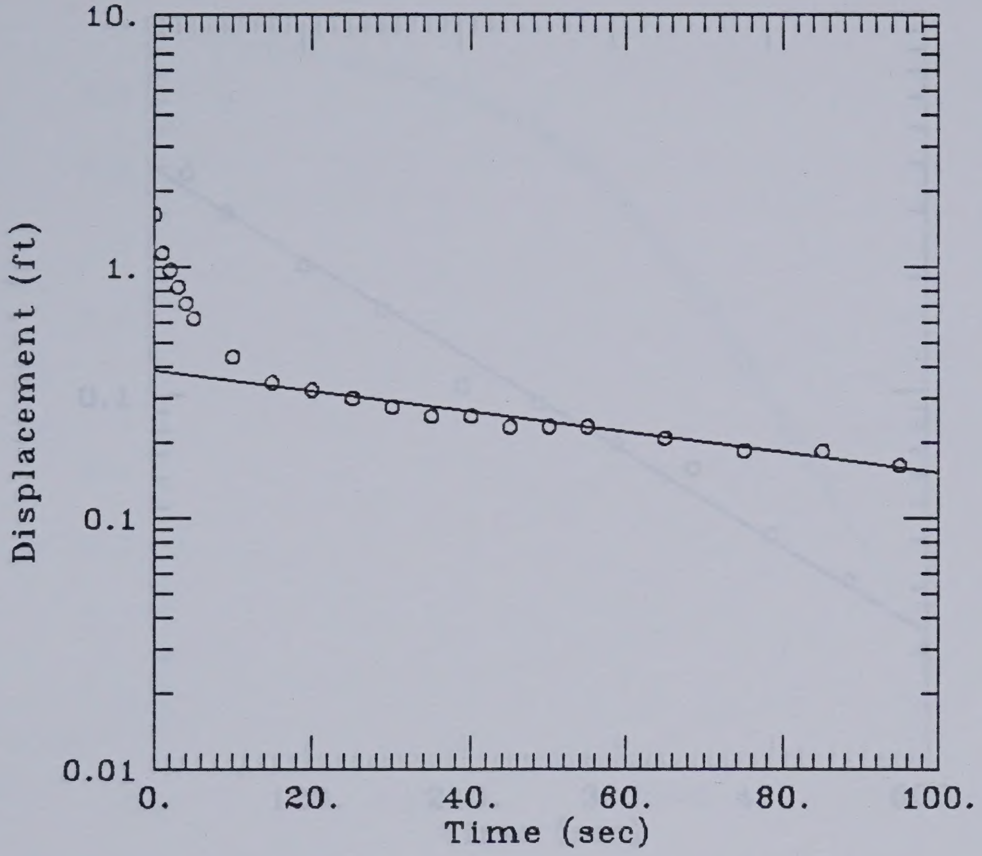
AQUIFER TYPE:
Confined
SOLUTION METHOD:
Cooper et al.

ESTIMATED PARAMETERS:
T = 0.0001305 ft^2/sec
S = 0.011

TEST DATA:
H0 = 1.8 ft
rc = 0.08333 ft
rw = 0.25 ft

MW-1 Slug Out

GeoResearch, Inc.	Client: **City of Laurel**
Project No.: **112035**	Location: **Laurel Landfill**



DATA SET:
12out.dat
12/29/92

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice

ESTIMATED PARAMETERS:
K = 3.2866E-05 ft/sec
y0 = 0.3858 ft

TEST DATA:
H0 = 1.617 ft
rc = 0.08333 ft
rw = 0.25 ft
L = 1. ft
b = 1. ft
H = 1. ft

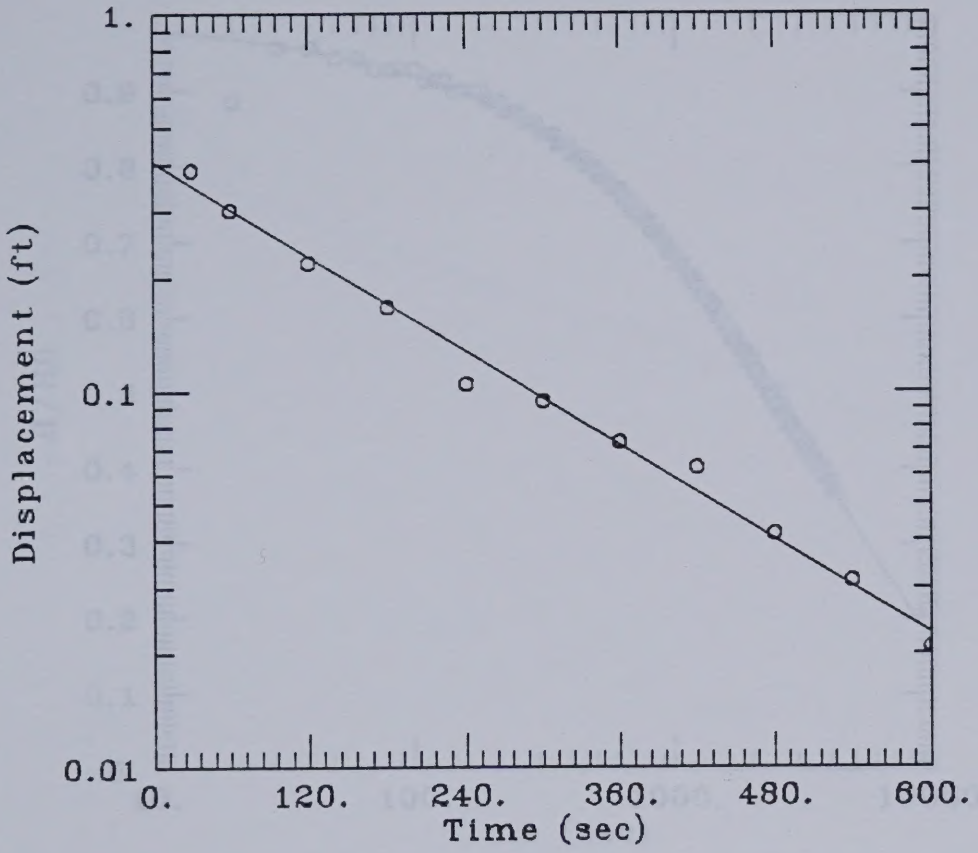
MW-2 Slug Out

GeoResearch, Inc.

Client: **City of Laurel**

Project No.: **112035**

Location: **Laurel Landfill**



DATA SET:
laurmw-2.dat
12/29/92

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice

ESTIMATED PARAMETERS:
K = 1.5823E-05 ft/sec
y0 = 0.4048 ft

TEST DATA:
H0 = 1.2 ft
rc = 0.08333 ft
rw = 0.25 ft
L = 1.2 ft
b = 1.2 ft
H = 1.2 ft

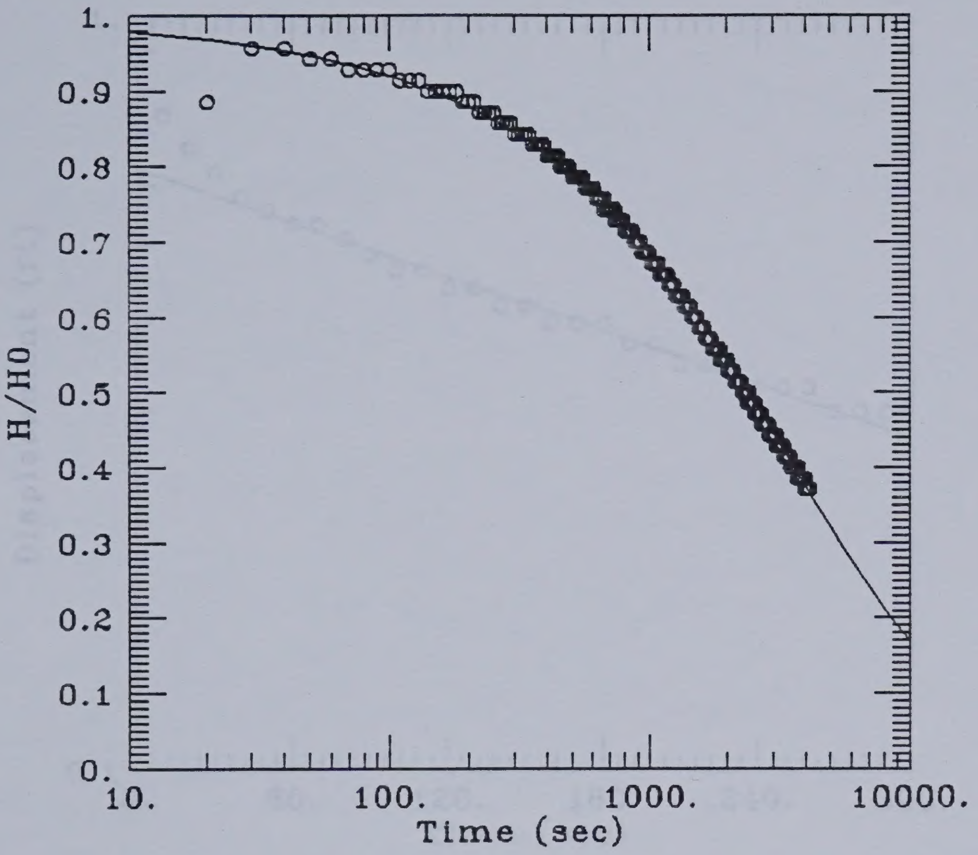
MW-2 Slug Out

GeoResearch, Inc.

Client: **City of Laurel**

Project No.: **112035**

Location: **Laurel Landfill**



DATA SET:
lmw-3in.dat
12/29/92

AQUIFER TYPE:
Confined

SOLUTION METHOD:
Cooper et al.

ESTIMATED PARAMETERS:
T = 1.8982E-06 ft^2/sec
S = 0.003

TEST DATA:
H0 = 1.617 ft
rc = 0.08333 ft
rw = 0.25 ft

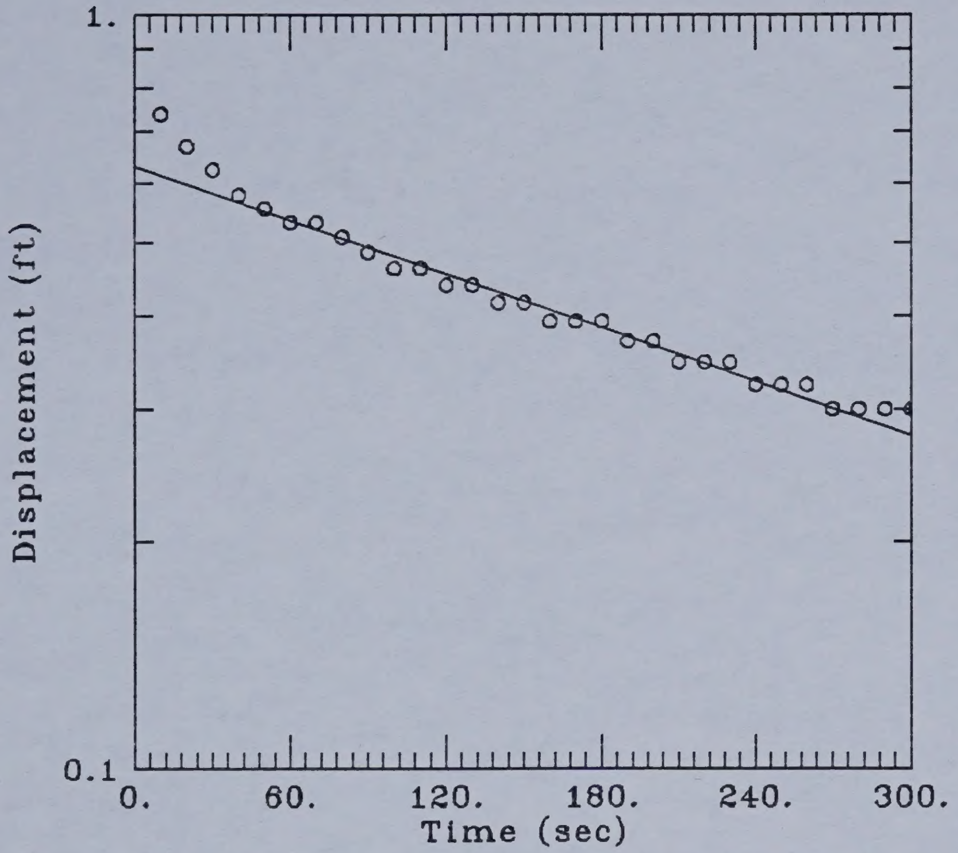
MW-3 Slug In

GeoResearch, Inc.

Client: **City of Laurel**

Project No.: **112035**

Location: **Laurel Landfill**



DATA SET:
14out.dat
12/29/92

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice

ESTIMATED PARAMETERS:
K = 9.7016E-06 ft/sec
y0 = 0.6309 ft

TEST DATA:
H0 = 1.617 ft
rc = 0.08333 ft
rw = 0.25 ft
L = 1. ft
b = 1. ft
H = 1. ft

MW-4 Slug Out

GeoResearch, Inc.	Client: **City of Laurel**
Project No.: **112035**	Location: **Laurel Landfill**

APPENDIX G

LABORATORY REPORTS

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48610
DATE: 12/08/92 da

WATER ANALYSIS

Project No. 112035
Laurel Landfill
MW-1
Sampled 11/14/92 @ 0935
Submitted 11/16/92

Constituent	mg/l (ppm)	
Potassium	41	
Sodium	4570	
Calcium	413	
Magnesium	4040	
Sulfate	25000	
Chloride	191	
Carbonate	0	
Bicarbonate	1050	
Total Dissolved Solids @ 180° C	38700	
Total Alkalinity as $CaCO_3$	864	
Specific Conductance @ 25° C	26900	µmhos/cm
pH	6.8	s.u.
Nitrate as N	<0.05	
Ammonia as N	0.3	
Chemical Oxygen Demand	39	
Total Suspended Solids	1050	
Total Cyanide	<0.005	

Dissolved Metals	
Arsenic	0.016
Barium	<0.1
Cadmium	<0.01*
Chromium	<0.1*
Iron	<0.3*
Lead	<0.1*
Manganese	11.2
Mercury	<0.005*
Selenium	<0.005
Silver	<0.06*

*Detection limit raised due to sample matrix interferences.

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.

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FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48612
DATE: 12/08/92 da

WATER ANALYSIS

Project No. 112035
Laurel Landfill
MW-5
Sampled 11/14/92 @ 0940
Submitted 11/16/92

Constituent	mg/l (ppm)	
Potassium	39	
Sodium	4580	
Calcium	415	
Magnesium	4000	
Sulfate	25100	
Chloride	193	
Carbonate	0	
Bicarbonate	1060	
Total Dissolved Solids @ 180° C	39000	
Total Alkalinity as $CaCO_3$	868	
Specific Conductance @ 25° C	27000	µmhos/cm
pH	6.9	s.u.
Nitrate as N	<0.05	
Ammonia as N	0.4	
Chemical Oxygen Demand	41	
Total Suspended Solids	720	
Total Cyanide	<0.005	
Dissolved Metals		
Arsenic	<0.005	
Barium	<0.1	
Cadmium	<0.01*	
Chromium	<0.1*	
Iron	<0.3*	
Lead	<0.1*	
Manganese	10.5	
Mercury	<0.005*	
Selenium	<0.005	
Silver	<0.06*	

*Detection limit raised due to sample matrix interferences.

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.

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FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48610 dup
DATE: 12/08/92 da

QUALITY ASSURANCE-DUPLICATE ANALYSIS

Project No. 112035
Laurel Landfill
MW-1
Sampled 11/14/92 @ 0935
Submitted 11/16/92

Constituent	mg/l (ppm)	
Potassium	38	
Sodium	4480	
Calcium	411	
Magnesium	3990	
Sulfate	25000	
Chloride	188	
Carbonate	0	
Bicarbonate	1060	
Total Dissolved Solids @ 180° C	38600	
Total Alkalinity as $CaCO_3$	870	
Specific Conductance @ 25° C	27000	μmhos/cm
pH	6.8	s.u.
Nitrate as N	<0.05	
Ammonia as N	0.3	
Chemical Oxygen Demand	40	
Total Suspended Solids	1050	
Total Cyanide	<0.005	

Dissolved Metals	
Arsenic	0.014
Barium	<0.1
Cadmium	<0.01*
Chromium	<0.1*
Iron	<0.3*
Lead	<0.1*
Manganese	11.3
Mercury	<0.005*
Selenium	<0.005
Silver	<0.06*

*Detection limit raised due to sample matrix interferences.

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.

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FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48611
DATE: 12/08/92 da

WATER ANALYSIS

Project No. 112035
Laurel Landfill
MW-2
Sampled 11/13/92 @ 1515
Submitted 11/16/92

Constituent	mg/l (ppm)	
Potassium	33	
Sodium	2300	
Calcium	404	
Magnesium	2890	
Sulfate	16400	
Chloride	199	
Carbonate	0	
Bicarbonate	602	
Total Dissolved Solids @ 180° C	24400	
Total Alkalinity as $CaCO_3$	494	
Specific Conductance @ 25° C	18800	µmhos/cm
pH	7.0	s.u.
Nitrate as N	51.5	
Ammonia as N	<0.1	
Chemical Oxygen Demand	53	
Total Suspended Solids	3430	
Total Cyanide	<0.005	
Dissolved Metals		
Arsenic	<0.05*	
Barium	<0.1	
Cadmium	0.024	
Chromium	<0.1*	
Iron	<0.3*	
Lead	<0.1*	
Manganese	0.13	
Mercury	<0.005*	
Selenium	0.89	
Silver	<0.06*	

*Detection limit raised due to sample matrix interferences.

ENERGY LABORATORIES

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LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48609
DATE: 12/08/92 da

WATER ANALYSIS

Project No. 112035
Laurel Landfill
MW-3
Sampled 11/13/92 @ 1340
Submitted 11/16/92

Constituent	mg/l (ppm)	
Potassium	28	
Sodium	10500	
Calcium	364	
Magnesium	715	
Sulfate	23900	
Chloride	354	
Carbonate	0	
Bicarbonate	1460	
Total Dissolved Solids @ 180° C	36100	
Total Alkalinity as $CaCO_3$	1200	
Specific Conductance @ 25° C	33800	µmhos/cm
pH	7.4	s.u.
Nitrate as N	0.14	
Ammonia as N	4.5	
Chemical Oxygen Demand	10	
Total Suspended Solids	1900	
Total Cyanide	<0.005	

Dissolved Metals	
Arsenic	0.005
Barium	<0.1
Cadmium	<0.01*
Chromium	<0.1*
Iron	1.11
Lead	<0.1*
Manganese	0.32
Mercury	<0.005*
Selenium	<0.005
Silver	0.404

*Detection limit raised due to sample matrix interferences.

ENERGY LABORATORIES

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FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48608
DATE: 12/08/92 da

WATER ANALYSIS

Project No. 112035
Laurel Landfill
MW-4
Sampled 11/13/92 @ 1220
Submitted 11/16/92

Constituent	mg/l (ppm)	
Potassium	27	
Sodium	954	
Calcium	421	
Magnesium	850	
Sulfate	5530	
Chloride	96	
Carbonate	0	
Bicarbonate	711	
Total Dissolved Solids @ 180° C	8830	
Total Alkalinity as $CaCO_3$	583	
Specific Conductance @ 25° C	8210	µmhos/cm
pH	7.2	s.u.
Nitrate as N	1.29	
Ammonia as N	0.3	
Chemical Oxygen Demand	20	
Total Suspended Solids	2820	
Total Cyanide	<0.005	

Dissolved Metals	
Arsenic	<0.005
Barium	<0.1
Cadmium	<0.001
Chromium	<0.01
Iron	<0.3*
Lead	<0.1*
Manganese	1.00
Mercury	<0.005*
Selenium	0.18
Silver	<0.005

*Detection limit raised due to sample matrix interferences.

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LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48613
DATE: 12/08/92 da

WATER ANALYSIS

Project No. 112035
Laurel Landfill
MW-6
Sampled 11/14/92 @ 1110
Submitted 11/16/92

Constituent	mg/l (ppm)	
Potassium	<1	
Sodium	<1	
Calcium	<1	
Magnesium	<1	
Sulfate	2	
Chloride	<1	
Carbonate	0	
Bicarbonate	2	
Total Dissolved Solids @ 180° C	6	
Total Alkalinity as $CaCO_3$	2	
Specific Conductance @ 25° C	7	µmhos/cm
pH	5.8	s.u.
Nitrate as N	<0.05	
Ammonia as N	<0.1	
Chemical Oxygen Demand	2	
Total Suspended Solids	<1	
Total Cyanide	<0.005	
Dissolved Metals		
Arsenic	<0.005	
Barium	<0.1	
Cadmium	<0.001	
Chromium	<0.01	
Iron	<0.03	
Lead	<0.01	
Manganese	<0.02	
Mercury	<0.001	
Selenium	<0.005	
Silver	<0.005	

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LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48611 spi
DATE: 12/08/92 da

QUALITY ASSURANCE-SPIKED ANALYSIS

Project No. 112035
Laurel Landfill
MW-2
Sampled 11/13/92 @ 1515
Submitted 11/16/92

Constituent	% Recovery	
Potassium	100	
Sodium	99	
Calcium	100	
Magnesium	100	
Sulfate	100	
Chloride	99	
Carbonate	N/A	
Bicarbonate	N/A	
Total Dissolved Solids @ 180° C	N/A	
Total Alkalinity as $CaCO_3$	N/A	
Specific Conductance @ 25° C	N/A	µmhos/cm
pH	N/A	s.u.
Nitrate as N	96	
Ammonia as N	87	
Chemical Oxygen Demand	101	
Total Suspended Solids	N/A	
Total Cyanide	94	
Dissolved Metals		
Arsenic	81	*
Barium	107	
Cadmium	98	
Chromium	*	
Iron	*	
Lead	*	
Manganese	96	
Mercury	98	
Selenium	*	
Silver	*	

*Unable to get spike recovery due to matrix interferences.

ENERGY LABORATORIES

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LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48610
DATE: 12/03/92 ag

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill, MW-1
Sampled 11/14/92 @ 0935
Submitted 11/16/92

Constituent	μg/l	Constituent	μg/l
Benzene	<1.0	1,1-Dichloroethane	<1.0
Bromochloromethane	<1.0	1,2-Dichloroethane	<1.0
Bromodichloromethane	<1.0	Iodomethane	<1.0
cis-1,3-Dichloropropene	<1.0	Methylene chloride	<1.0
trans-1,3-Dichloropropene	<1.0	1,1-Dichloroethene	<1.0
1,4-Difluorobenzene	<1.0	trans-1,2-Dichloroethene	<1.0
Ethylbenzene	<1.0	Styrene	<1.0
Ethyl methacrylate	<1.0	1,1,2,2-Tetrachloroethane	<1.0
4-Bromofluorobenzene	<10	Toluene	<1.0
Bromoform	<1.0	1,1,1-Trichloroethane	<1.0
Bromomethane	<1.0	1,1,2-Trichloroethane	<1.0
Carbon tetrachloride	<1.0	Trichloroethene	<1.0
Chlorobenzene	<1.0	Trichlorofluoromethane	<1.0
Dibromochloromethane	<1.0	1,2,3-Trichloropropane	<1.0
Chloroethane	<1.0	Vinyl acetate	<20
2-Chloroethyl vinyl ether	<1.0	Vinyl chloride	<1.0
Chloroform	<1.0	Xylenes	<1.0
Chloromethane	<1.0	Tetrachloroethene	<1.0
Dibromomethane	<1.0		
Dichlorodifluoromethane	<1.0		

NOTE: Analysis done by EPA method 8240.

ENERGY LABORATORIES

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FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48611
DATE: 12/03/92 ag

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill, MW-2
Sampled 11/13/92 @ 1515
Submitted 11/16/92

Constituent	µg/l	Constituent	µg/l
Benzene	<1.0	1,1-Dichloroethane	<1.0
Bromochloromethane	<1.0	1,2-Dichloroethane	<1.0
Bromodichloromethane	<1.0	Iodomethane	<1.0
cis-1,3-Dichloropropene	<1.0	Methylene chloride	2.0
trans-1,3-Dichloropropene	<1.0	1,1-Dichloroethene	<1.0
1,4-Difluorobenzene	<1.0	trans-1,2-Dichloroethene	<1.0
Ethylbenzene	<1.0	Styrene	<1.0
Ethyl methacrylate	<1.0	1,1,2,2-Tetrachloroethane	<1.0
4-Bromofluorobenzene	<10	Toluene	<1.0
Bromoform	<1.0	1,1,1-Trichloroethane	<1.0
Bromomethane	<1.0	1,1,2-Trichloroethane	<1.0
Carbon tetrachloride	<1.0	Trichloroethene	<1.0
Chlorobenzene	<1.0	Trichlorofluoromethane	<1.0
Dibromochloromethane	<1.0	1,2,3-Trichloropropane	<1.0
Chloroethane	<1.0	Vinyl acetate	<20
2-Chloroethyl vinyl ether	<1.0	Vinyl chloride	<1.0
Chloroform	<1.0	Xylenes	<1.0
Chloromethane	<1.0	Tetrachloroethene	<1.0
Dibromomethane	<1.0		
Dichlorodifluoromethane	4.3		

NOTE: Analysis done by EPA method 8240.

ENERGY LABORATORIES

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LABORATORY REPORT

TO:	GeoResearch, Inc.	**LAB NO.:**	92-48609
ADDRESS:	P.O. Box 5597 Helena, MT 59604	**DATE:**	12/03/92 ag

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill, MW-3
Sampled 11/13/92 @ 1340
Submitted 11/16/92

Constituent	µg/l	Constituent	µg/l
Benzene	<1.0	1,1-Dichloroethane	<1.0
Bromochloromethane	<1.0	1,2-Dichloroethane	<1.0
Bromodichloromethane	<1.0	Iodomethane	<1.0
cis-1,3-Dichloropropene	<1.0	Methylene chloride	<1.0
trans-1,3-Dichloropropene	<1.0	1,1-Dichloroethene	<1.0
1,4-Difluorobenzene	<1.0	trans-1,2-Dichloroethene	<1.0
Ethylbenzene	<1.0	Styrene	<1.0
Ethyl methacrylate	<1.0	1,1,2,2-Tetrachloroethane	<1.0
4-Bromofluorobenzene	<10	Toluene	<1.0
Bromoform	<1.0	1,1,1-Trichloroethane	<1.0
Bromomethane	<1.0	1,1,2-Trichloroethane	<1.0
Carbon tetrachloride	<1.0	Trichloroethene	<1.0
Chlorobenzene	<1.0	Trichlorofluoromethane	<1.0
Dibromochloromethane	<1.0	1,2,3-Trichloropropane	<1.0
Chloroethane	<1.0	Vinyl acetate	<20
2-Chloroethyl vinyl ether	<1.0	Vinyl chloride	<1.0
Chloroform	<1.0	Xylenes	<1.0
Chloromethane	<1.0	Tetrachloroethene	<1.0
Dibromomethane	<1.0		
Dichlorodifluoromethane	<1.0		

NOTE: Analysis done by EPA method 8240.

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48608
DATE: 12/03/92 ag

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill, MW-4
Sampled 11/13/92 @ 1220
Submitted 11/16/92

Constituent	µg/l	Constituent	µg/l
Benzene	<1.0	1,1-Dichloroethane	<1.0
Bromochloromethane	<1.0	1,2-Dichloroethane	<1.0
Bromodichloromethane	<1.0	Iodomethane	<1.0
cis-1,3-Dichloropropene	<1.0	Methylene chloride	<1.0
trans-1,3-Dichloropropene	<1.0	1,1-Dichloroethene	<1.0
1,4-Difluorobenzene	<1.0	trans-1,2-Dichloroethene	<1.0
Ethylbenzene	<1.0	Styrene	<1.0
Ethyl methacrylate	<1.0	1,1,2,2-Tetrachloroethane	<1.0
4-Bromofluorobenzene	<10	Toluene	<1.0
Bromoform	<1.0	1,1,1-Trichloroethane	<1.0
Bromomethane	<1.0	1,1,2-Trichloroethane	<1.0
Carbon tetrachloride	<1.0	Trichloroethene	<1.0
Chlorobenzene	<1.0	Trichlorofluoromethane	<1.0
Dibromochloromethane	<1.0	1,2,3-Trichloropropane	<1.0
Chloroethane	<1.0	Vinyl acetate	<20
2-Chloroethyl vinyl ether	<1.0	Vinyl chloride	<1.0
Chloroform	<1.0	Xylenes	<1.0
Chloromethane	<1.0	Tetrachloroethene	<1.0
Dibromomethane	<1.0		
Dichlorodifluoromethane	<1.0		

NOTE: Analysis done by EPA method 8240.

ENERGY
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LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48612
DATE: 12/03/92 ag

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill, MW-5
Sampled 11/14/92 @ 0940
Submitted 11/16/92

Constituent	µg/l	Constituent	µg/l
Benzene	<1.0	1,1-Dichloroethane	<1.0
Bromochloromethane	<1.0	1,2-Dichloroethane	<1.0
Bromodichloromethane	<1.0	Iodomethane	<1.0
cis-1,3-Dichloropropene	<1.0	Methylene chloride	<1.0
trans-1,3-Dichloropropene	<1.0	1,1-Dichloroethene	<1.0
1,4-Difluorobenzene	<1.0	trans-1,2-Dichloroethene	<1.0
Ethylbenzene	<1.0	Styrene	<1.0
Ethyl methacrylate	<1.0	1,1,2,2-Tetrachloroethane	<1.0
4-Bromofluorobenzene	<10	Toluene	<1.0
Bromoform	<1.0	1,1,1-Trichloroethane	<1.0
Bromomethane	<1.0	1,1,2-Trichloroethane	<1.0
Carbon tetrachloride	<1.0	Trichloroethene	<1.0
Chlorobenzene	<1.0	Trichlorofluoromethane	<1.0
Dibromochloromethane	<1.0	1,2,3-Trichloropropane	<1.0
Chloroethane	<1.0	Vinyl acetate	<20
2-Chloroethyl vinyl ether	<1.0	Vinyl chloride	<1.0
Chloroform	<1.0	Xylenes	<1.0
Chloromethane	<1.0	Tetrachloroethene	<1.0
Dibromomethane	<1.0		
Dichlorodifluoromethane	<1.0		

NOTE: Analysis done by EPA method 8240.

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48613
DATE: 12/03/92 ag

WATER ANALYSIS

Proj. No. 112035, Laurel Landfill, MW-6
Sampled 11/14/92 @ 1110
Submitted 11/16/92

Constituent	µg/l	Constituent	µg/l
Benzene	<1.0	1,1-Dichloroethane	<1.0
Bromochloromethane	<1.0	1,2-Dichloroethane	<1.0
Bromodichloromethane	<1.0	Iodomethane	<1.0
cis-1,3-Dichloropropene	<1.0	Methylene chloride	4.1
trans-1,3-Dichloropropene	<1.0	1,1-Dichloroethene	<1.0
1,4-Difluorobenzene	<1.0	trans-1,2-Dichloroethene	<1.0
Ethylbenzene	<1.0	Styrene	<1.0
Ethyl methacrylate	<1.0	1,1,2,2-Tetrachloroethane	<1.0
4-Bromofluorobenzene	<10	Toluene	<1.0
Bromoform	<1.0	1,1,1-Trichloroethane	<1.0
Bromomethane	<1.0	1,1,2-Trichloroethane	<1.0
Carbon tetrachloride	<1.0	Trichloroethene	<1.0
Chlorobenzene	<1.0	Trichlorofluoromethane	<1.0
Dibromochloromethane	<1.0	1,2,3-Trichloropropane	<1.0
Chloroethane	<1.0	Vinyl acetate	<20
2-Chloroethyl vinyl ether	<1.0	Vinyl chloride	<1.0
Chloroform	1.7	Xylenes	<1.0
Chloromethane	<1.0	Tetrachloroethene	<1.0
Dibromomethane	<1.0		
Dichlorodifluoromethane	<1.0		

NOTE: Analysis done by EPA method 8240.

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P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO:	GeoResearch, Inc.	**LAB NO.:**	92-48608-13
ADDRESS:	P.O. Box 5597 Helena, MT 59604	**DATE:**	12/03/92 ag

WATER VOLATILE SURROGATE RECOVERY

10 μg/l Surrogate Standard Spike

	------% recovery------		
SAMPLE NO.	S1 (TOL)#	S2 (BFB)#	S3 (DCE)#
92-48608	117	105	106
92-48609	97	89	111
92-48610	99	90	114
92-48611	109	99	120
92-48612	99	96	120
92-48613	111	98	102

	QC LIMITS, % Recovery
S1 (TOL) = Toluene-d8	80-120
S2 (BFB) = Bromofluorobenzene	80-120
S3 (DCE) = 1,2-Dichloroethane-d4	80-120

#Column to be used to flag recovery values with an asterisk.

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.

P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: GeoResearch, Inc.
ADDRESS: P.O. Box 5597
Helena, MT 59604

LAB NO.: 92-48608-13
DATE: 12/03/92 ag

WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Spike Added, µg/l	Sample Concentration µg/l	MS Concentration µg/l	MS % Rec. #	QC. Limits Rec., %
1,1-Dichloroethene	5.0	< 1.0	3.3	66	60-140
Trichloroethene	5.0	< 1.0	4.3	86	60-140
Benzene	5.0	< 1.0	5.1	102	60-140
Toluene	5.0	< 1.0	5.8	116	60-140
Chlorobenzene	5.0	< 1.0	5.5	110	60-140

Compound	Spike Added µg/l	MSD Concentration µg/l	MSD % Rec. #	% RPD #	QC Limits, RPD, %	Rec., %
1,1-Dichloroethene	5.0	3.2	64	2.0	14	60-140
Trichloroethene	5.0	4.1	82	4.8	14	60-140
Benzene	5.0	4.7	94	8.2	11	60-140
Toluene	5.0	5.0	100	15	13	60-140
Chlorobenzene	5.0	4.9	98	12	13	60-140

# Column to be used to flag recovery and RPD values with an asterisk.

GRI GeoResearch, Inc.

CHAIN OF CUSTODY RECORD

910- HELENA • HELENA, MONTANA 59601
TEL. (406) 449-3225
FAX (406) 449-2371

PROJ. NO.	PROJECT NAME
112035	LAUREL LAND FILL

SAMPLERS: *(Signature)*

STAT. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	STATE SOLID WASTE LIST (ATTACHED) 8260	COD	DISS. METALS	COMMONS / PROPERTIES			REMARKS
MW-4	11-13	11:50		X	MW-4 40 mL	3	X						HCl
"	"	12:00		X	" 250 mL	1		X					H_2SO_4
"	"	12:10		X	" 250 mL	1			X				FILTERED + HNO_3
"	"	12:25		X	" 1 L	1				X			NONE
MW-3	11-13	13:35		X	MW-3 40 mL	3	X						HCl
"	"	13:40		X	" 250 mL	1		X					H_2SO_4
"	"	14:00		X	" 250 mL	1			X				FILTERED + HNO_3
"	"	14:05		X	" 1 L	1				X			NONE
MW-7	11-14	9:20		X	MW-7 40 mL	3	X						HCl
"	"	9:35		X	" 250 mL	1		X					H_2SO_4
"	"	9:55		X	" 250 mL	1			X				FILTERED + HNO_3
"	"	10:10		X	" 1 L	1				X			NONE

Relinquished *(Signature)*	Date/Time	Received by: *(Signature)*	Relinguished by: *(Signature)*	Date/Time	Received by: *(Signature)*
Darold Bernke	11-16-92 9:55				

Relinquished *(Signature)*	Date/Time	Received by: *(Signature)*	Relinguished by: *(Signature)*	Date/Time	Received by: *(Signature)*

Relinquished *(Signature)*	Date/Time	Received for Laboratory by: *(Signature)*	Date/Time	Remarks
		Pam Stevenson	11/16/92 0957	

Split Samples:
[] Accepted [] Declined ______ Signature

GRI GeoResearch, Inc.

CHAIN OF CUSTODY RECORD

910- HELENA • HELENA, MONTANA 59601
TEL. (406) 449-3225
FAX (406) 449-2371

PROJ. NO. 112035

PROJECT NAME LAUREL LANDFILL

SAMPLERS: (Signature)

STAT. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	STATE SOLIDWASTE LIST 8260	COD	DISS. METALS	COMMON / PROPERTIES			REMARKS
MW-2	11-13	15:10		x	MW-2 40 mL	3	x						HCl
"	"	15:15		x	" 250 mL	1		x					H_2SO_4
"	"	15:25		x	" 250 mL	1			x				FILTERED + HNO_3
"	"	15:30		x	" 1 L	1				x			NONE
MW-5	11-14	9:25		x	MW-5 40 mL	3	x						HCl
"		9:40		x	" 250 mL	1		x					H_2SO_4
"		10:00		x	" 250 mL	1			x				FILTERED + HNO_3
"		10:15		x	" 1 L	1				x			NONE
MW-6	11-14	11:00		x	MW-6 40 mL	3	x						HCl
"	"	11:10		x	" 250 mL	1		x					H_2SO_4
"	"	11:15		x	" 250 mL	1			x				FILTERED + HNO_3
"	"	11:20		x	" 1 L	1				x			NONE

Relinquished (Signature) Darold Berube	Date/Time 11-16-92 9:55	Received by: (Signature)	Relinguished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished (Signature)	Date/Time	Received by: (Signature)	Relinguished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished (Signature)	Date/Time	Received for Laboratory by: (Signature) Pam Stevenson	Date/Time 11/16/92 0957	Remarks	

Split Samples:
☐ Accepted ☐ Declined ______ Signature

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[illegible]

GEORESEARCH, INC

Work Plan for a Hydro-Geological and Soils Investigation at the City of Laurel Landfill

September 4, 1992

GEO RESEARCH®

what about
the subtitled
staggered
implementation
schedule for
GW monitoring?
Does that
apply?
O.K. JD

DEPARTMENT OF
HEALTH AND ENVIRONMENTAL SCIENCES

Solid and Hazardous Waste Bureau
Solid Waste Program

STAN STEPHENS, GOVERNOR (406) 444-1430 FAX #(406) 444-1499

STATE OF MONTANA

OFFICE LOCATION: 836 Front Street, Helena, Montana

MAILING ADDRESS: Cogswell Building, Helena, MT 59620

October 1, 1992

Mr. Chuck Rogers, Mayor
City of Laurel
P.O. Box 10
Laurel, Montana 59044

RE: **LAUREL CLASS II LANDFILL, YELLOWSTONE COUNTY**
LICENSE NO. 203
REVIEW OF THE WORKPLAN FOR THE HYDROGEOLOGICAL AND SOILS STUDY.

Dear Mr. Rogers:

On September 9, 1992, the Montana Department of Health and Environmental Sciences Solid Waste Program (the Department) received the Workplan for the above-referenced facility from Mr. Curt Coover, Project Hydrogeologist with GeoResearch, Inc. on behalf of the City of Laurel.

The following comments, corrections and deficiencies are presented in the order in which they appear in the Workplan and are numbered accordingly by applicable section. These items will need to be addressed before the Workplan can be approved by the Department:

1.0 INTRODUCTION

Specifically, 40 CFR Part 258, Subpart E (i.e. "Subtitle D" groundwater monitoring requirements become effective on October 9, 1993. Therefore, the site would have to be closed by October 9, 1993 (not 1994, as stated in the Workplan text) for the federal requirements for groundwater monitoring to be non-applicable.

2.0 SITE DESCRIPTION

A. The old site (license no. 24) is not required to have a groundwater monitoring plan because it does not meet the criteria according to Section 75-10-207(1), Montana Code Annotated (MCA), [not Section 75-10-204(5), MCA, which outlines the powers and duties of the Department].

"AN EQUAL OPPORTUNITY EMPLOYER"

D. Is this
required
under the
GW rules?

Please explain.

Jack

B. In reference to the landfill areas shown on Figure 2-2 of this Workplan, where was the "old dump site" located which was opened in 1965?

C. Provide a contour map showing the topography and drainage of this site since cover has been applied.

Enclosed is a copy of the originally undisturbed site topography. Please note the high area in approx the center of the south line (i.e. elev. is 3558.62). The proposed location of MW4 will monitor the intermittent drainage coulee to the SE. Please provide a more specific proposed location for MW2. Will it be located west of the (original topo high spot to monitor possible contam migration in the gndwtr to the SW? MW ② should this location (MW2) be located on the west side of the intermittent drainage to the SE.

D. Provide a map or descriptive list of the locations where specific wastes (i.e. asbestos, infectious waste, etc.) were buried at this facility, if available.

E. Explain why you think neither the shallow gravels mapped to the north of the site, nor the Yellowstone Valley gravel unit described as being south of the site will not be present at this site. Does this site represent a divide or permeability barrier between the north and south gravel deposits? What happens to the water in the shallow gravels to the north, if drainage is to the southeast?

F. The proposed maximum depth of drilling (150 feet) at the site must take into account the extent of the hydrogeologic units at the site. This would include establishing the thickness of the uppermost aquifer and determining the underlying confining layer in at least one boring [see ARM 16.14.703(1)(a)(iv)].

G. **FIGURE 2-2.** Please add "R-1" to the legend.

Need Scale,!

3.0 PROPOSED INVESTIGATION

3.1 Soil Investigation.

A. Additional reasons for not drilling through the refuse on-site are the possibility of introducing contamination down into the aquifer with the drilling equipment, and materials sloughing into the lower portion of the hole from the waste zone above.

B. Will soil samples collected for laboratory tests (i.e. grain size distribution, total organic carbon (TOC), soil pH, moisture content and density) be collected from both the unsaturated and saturated zones, except for moisture content which will be measured from unsaturated zone soil materials?

3.2 Groundwater Investigation.

A. Required groundwater sampling parameters are located in **Table 1** of ARM 16.14.706.

Pat -

There is a shallow (perched) seasonal and/or sporatic flow that was encounter at 10 feet in the west trench. You may want to look back in their file about 4 yrs. JD

B. It is also important to be cognizant of ARM 16.14.712(2) which states that if closure is not achieved by January 1, 1993, semi-annual sampling events will be required through the 30 year post-closure period.

C. Do you plan to drill the borings/monitoring wells in the labeled numeric order presented on the map in Figure 2-2?
Please refer to Drafts Comments on sec. 3.2.1

If gr.dwtr is not encountered in the "first 2 tst borings" and the "new" (first MW4 MW3)

D. ~~If the "first two test borings" [apparently MW-1 (background) and MW-2] are drilled to 150 feet without encountering groundwater~~, and the intent is to leave these holes "open" to monitor for groundwater seepage into the holes, consider the following:

1. If these boreholes are intended to be used for groundwater monitoring, they must initially be sealed at the surface, capped and locked following drilling. This is to prevent surface contamination due to run-on/run-off and/or any additional outside forces that might alter the natural quality of the water and possibly impact the aquifer. Sealed capped and locked monitoring wells also deter tampering and vandalism [see, ARM 16.14.705(7)].

2. Allowing borings to remain open/uncased for extended periods of time for the purposes of water collection from seepage zones in the open borehole, could allow contaminated water from shallow low permeability and/or low volume zones of moisture to run down the walls of the hole and mix/cross-contaminate deeper, unimpacted zones water-bearing zones [see, ARM 16.14.705(6)]. This will not be considered an acceptable procedure if borings are allowed to remain open (i.e. uncased) more than one day.

3. Slopewash, gravels and/or colluvium from the upper portion of the hole will probably slough sufficiently into the hole to naturally prevent leaving these boreholes open for any extended period of time (i.e over-night).

E. In the event that the first two test borings are dry, the suggestion presented in the Workplan requesting a no-migration petition may be considered by the Department. However, it is most likely that all four (4) proposed borings/monitoring wells will be required to adequately evaluate the soil characteristics and hydrologic conditions over the entire 10-acre site. Total depths of the borings

may be limited to at least 20 feet below the depth of buried waste, as well as reconsidering the value of any additional monitoring well installations.

Also, note that the depth of borings/monitor wells drilled at a site does not independently constitute sufficient conditions to request a no-migration petition. Soil characteristics such as homogeneity, and vertical and horizontal hydraulic conductivities are also essential elements in considering the site applicability for a no-migration petition.

Shallow gdwtr notification to monitor ~~know~~ seeps/~~aqu~~ perched/seasonal shallow grdwtr ~~bearing~~ zones at this site by clustering option MW locations, if inadequate volumes (1gpm) are not initially discovered

3.2.1 Number and Location of Monitoring Wells.

The proposed upgradient monitoring well location is off-site. Explain the ownership of the property where this well will be located, the terms under which you will be granted access, and monitoring well installation rights.

see "old topo" → Change proposed MW locations + order of drlg.

3.2.2 Monitoring Well Installation and Construction.

A. Decontamination of the drilling equipment is essential and should also be done prior to working on the site, as well as between borings [see, ARM 16.14.705(3) & (4)].

B. What screen lengths do you intend to use in each well? If you decide screen lengths greater than 10 feet will be used in monitoring well construction, please consider the dilution factor associated with extensive lengths of screen, and explain your reasoning for the proposed additional length of screened interval(s).

Based on previous knowledge (1982) that shallow gd wtr did accumulate in trench along west side of site these zones/gdwtr must be monitored, they must be monitored separately from the deeper aquifers by installation of MWs ~~between~~ 10 to 35' deep based on wtr &/or moisture content of soils

3.2.3 Hydraulic Conductivity.

A. Using the Guelph permeameter to determine hydraulic conductivity in the unsaturated zone (i.e. 2 to 4 feet deep), explain how "total (horizontal plus vertical) unsaturated hydraulic conductivity" is applicable. Can the horizontal and vertical values be determined separately? Explain how these numbers are used with relevance to the actual individual horizontal and vertical hydraulic conductivities.

Will these Guelph permeameter tests be single head or the standard-two head method? What is matrix flux potential and how is it measured? How do you arrive at the soil parameter value? From what data do you get the reservoir area, is this just around the borehole or does it represent the entire aquifer reservoir?

Possibly by supplying the Department with Soilmoisture Equipment Corp.'s operations manual and applicable data interpretations and/or calculations, the above questions can be addressed in the necessary detail. A diagram would be nice with descriptions of the equipment involved, such as the porous/ceramic(?) base to the permeameter and what part the "ring(s)" play in the installation of the equipment. Propriety information will be handled as such upon request. It will not become part of the general solid waste files which are open to the public.

B. The Workplan states that a "field saturated" vertical hydraulic conductivity test (i.e. R-1) will be "conducted" at a depth of "approximately" 10 feet. Define "field saturated". Explain how this test will be "conducted". Provide the procedure and methodology involved in attaining an accurate "field saturated" vertical hydraulic conductivity.

How deep must the single ring be driven into the bottom of the hole to eliminate the compacted/sand-blasting "skin" effect from the sides and bottom of the borehole caused by drilling?

3.2.4 Table 3-1
Why aren't groundwater samples collected for volatile organic compound (VOC) analysis preserved with hydrochloric acid? See, Table 4-1 from the U.S. EPA SW-846 Test Methods which is enclosed. This Table shows (in footnote #1) liquid volatile organics samples must be preserved with one of the three (3) types of preservatives listed (i.e. H_2SO_4, HCl or solid $NaHSO_4$).

3.2.5 Sample Procedures.
A. Please note in the text of this Workplan that GeoResearch's Standard Operating Procedures (SOP) provided in Appendix B of this Workplan is merely a preliminary sampling and analysis plan (SAP), designed to provide appropriate sampling methodology for initial groundwater sampling at the site. A site-specific SAP must be provided to the Department coincident with the Groundwater Monitoring Plan for Departmental approval.

B. See comments under "Appendix B" concerning GeoResearch's SOP.

3.2.6 QA/QC

A duplicate sample and complete duplicate laboratory analysis of one well (the particular monitoring well duplicated being varied with each sampling event) per sampling event is required according to ARM 16.14.706(1)(b)(i)(C)(II), not just when there is an "anomalous lab result. . ." as stated in the Workplan text.

Be aware that if an "anomalous lab result", contamination, etc. is detected in a sampling event, the Department may require one or more of the following, according to ARM 16.14.708(1):

(a) re-sample one or more of the monitoring wells;
(b) increase the frequency of groundwater sampling;
(c) conduct monitoring for additional parameters;
(d) install additional monitoring wells to define the nature and extent of contamination; or
(e) prepare a groundwater corrective action plan including an assessment of the impacts and a schedule of implementation for corrective action.

4.0 REPORT AND RECOMMENDATIONS

A. Please be sure to include the following in the Hydrogeological and Soils Study Report: cross section(s) of the site soil correlations and hydrogeologic relationships, a potentiometric surface map, descriptions and delineation of the lateral and vertical extent of the gravels (if encountered), and discuss and locate any man-made influences related to the site soils and hydrogeologic effects.

APPENDIX B -

Checklist 1.

Decontamination Materials should include methanol, hexane, or acetone for rinsing sampling equipment for organics. Nitric acid which is mentioned, or hydrochloric acid is used for rinsing equipment when sampling for inorganics.

2.7 Sample Containers and Preservation.

Marking water levels on sample containers may be one way to determine if leakage or tampering has occurred. Consider placing a seal or tape over the cap of the containers. This is an effective and recommended method to prevent tampering, especially when sample containers are filled to the top.

2.8 Measurement of Field Parameters.

When using field measurement devices/equipment, it is important to document in the field notebook the manufacturer's name, model, model number and equipment-specific identification number(s). This is done in the event that a particular piece of equipment develops some specific abnormalities discovered either prior to, or after use at the documented site.

To be able to address these questionable issues prior to implementing the Workplan at the Laurel Landfill site, may eliminate any confusion or misunderstanding concerning the necessary data to be acquired for the Hydrogeological and Soils Study Report and the Groundwater Monitoring Plan.

When submitting report(s) pertaining to the Hydrogeological and Soils Study, please provide four (4) copies of the documents to the Department [see, ARM 16.14.703(1)].

The Department hopes to work closely with you and GeoResearch to accomplish the necessary requirements and be able to draw accurate conclusions concerning the nature of the soils and the hydrogeology from the information acquired at this site. If you have any questions, please give me a call.

Sincerely,

Pat Potts

Pat Potts
Environmental Specialist

enclosure

cc: Kevin Chappell, Surface Management Bureau, Montana Department of State Lands, 1625 Eleventh Ave., Helena, MT 59620

Cal Cumin, Director of Public Works, Planning Department, 907 Avenue B, Billings, MT 59102

Dr. George Sheckleton, Yellowstone County Health Officer, City-County Health Department, P.O. Box 35033, Billings, MT 59107

file: sw\laurel.let

GEORESEARCH, INC.

GEO
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September 9, 1992

Mr. Jim Worthington
City of Laurel
P.O. Box 10
Laurel, Montana 59044

Subject: **Work Plan for a Hydrogeological and Soils Investigation at the City of Laurel Landfill**
Dated: September 4, 1992

Dear Jim:

We are pleased to present the enclosed "Work Plan for a Hydrogeological and Soils Investigation at the Laurel Landfill" dated September 4, 1992. At your request, a copy of this plan was submitted by us directly to the Solid and Hazardous Waste Bureau.

This work plan fulfills the initial requirements of the SHWB. If comments on the work plan are received, the comments will be addressed and submitted to SHWB within fifteen days of receipt. The investigation must be completed within 180 days following approval of the Work Plan.

We will be soliciting bids from drillers to complete the drilling and monitoring well installation portion of the work plan. We will be asking for bids from several area drillers including two in Laurel. I will tabulate the bids and submit them to you for your review prior to selection.

As always, it is a pleasure to work with you and we are pleased to hear that your recovery is progressing.

Very truly yours,

GeoResearch, Inc.

Curt Coover

Curt Coover, P.G.
Project Hydrogeologist

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SEP 0 9 1992
MONTANA DEPARTMENT OF HEALTH
AND ENVIRONMENTAL SCIENCES
SOLID AND HAZARDOUS WASTE BUREAU

cc: Pat Potts, Solid and Hazardous Waste Bureau

910 Helena Avenue
Helena, MT 59601
TEL. (406) 449-3225
FAX (406) 449-2371

WORK PLAN
FOR A
HYDROGEOLOGICAL AND SOILS INVESTIGATION
AT THE
CITY OF LAUREL LANDFILL

Prepared for:

City of Laurel
P.O. Box 10
Laurel, Montana 59044

Prepared by:

GeoResearch, Inc.
115 North Broadway
Billings, Montana 59101
(406) 248-6771

September 4, 1992

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MONTANA DEPARTMENT OF HEALTH
AND ENVIRONMENTAL SCIENCES
SOLID AND HAZARDOUS WASTE BUREAU

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APPENDICES

Appendix A Nearby Water Well Logs
Appendix B GeoResearch Standard Operating Procedures

1994 →
? →
not apply

1994 ?

Oct.
1993

1.0 INTRODUCTION

GeoResearch, Inc. has been retained by the City of Laurel to conduct a hydrogeological and soils investigation at the Laurel landfill. The investigation was required in a letter to the City of Laurel from the Solid Waste Program dated May 8, 1992. Among other tasks, the letter required the City to conduct a hydrogeological and soils study and to monitor ground water. The specific requirements for conducting the study are described in Subchapter 7 of Title 16, Chapter 14 of the Administrative Rules of Montana. The study is to be completed within 180 days following state approval of this work plan. Since the site will be closed prior to 1994, RCRA Subtitle D rules for ground water monitoring will not apply this site.

The landfill has not been extensively used since September, 1990 and City waste is currently being hauled to the Billings landfill. A large amount of used shingles was temporarily placed at the site following a boom in reroofing resulting from a hail storm in June, 1991. The shingles were eventually hauled to the Billings landfill over a period of several months. Closure activities are being conducted concurrent with this hydrogeological investigation and final closure is anticipated to be completed within the next several months.

Where is "old dump site" located?

75-10-204(5)

?

2.0 SITE DESCRIPTION

The landfill, located on Buffalo Trail (State Route 532) approximately one and one half mile north of Laurel, is owned by the Montana Department of State Lands and operated by the City of Laurel under a right-of-way easement. A vicinity map showing the location of the site is presented on Figure 2-1. The site consists of two parcels totaling approximately 20 acres. The present landfill consists of 10.02 acres located in the northwest quarter of Section 33, Township 1 South, Range 24 East. The present parcel was licensed in 1982 as an expansion to a ten acre site located in the northwest quarter of Section 33 which was licensed in 1978. This work plan specifically addresses the new site (License #203) which was in operation in October, 1989. The older site immediately to the north (License #24) was closed in 1983 and §75.10.204(5) MCA does not apply and an investigation is not required at this time. However, the impact of the older site on the ground water at the current site will be taken into account when interpreting the data collected during this study. An old dump site which was opened in 1965 is not included in the scope of work. For the purposes of this work plan, "site" refers to the currently licensed (#203) 10.02 acre facility.

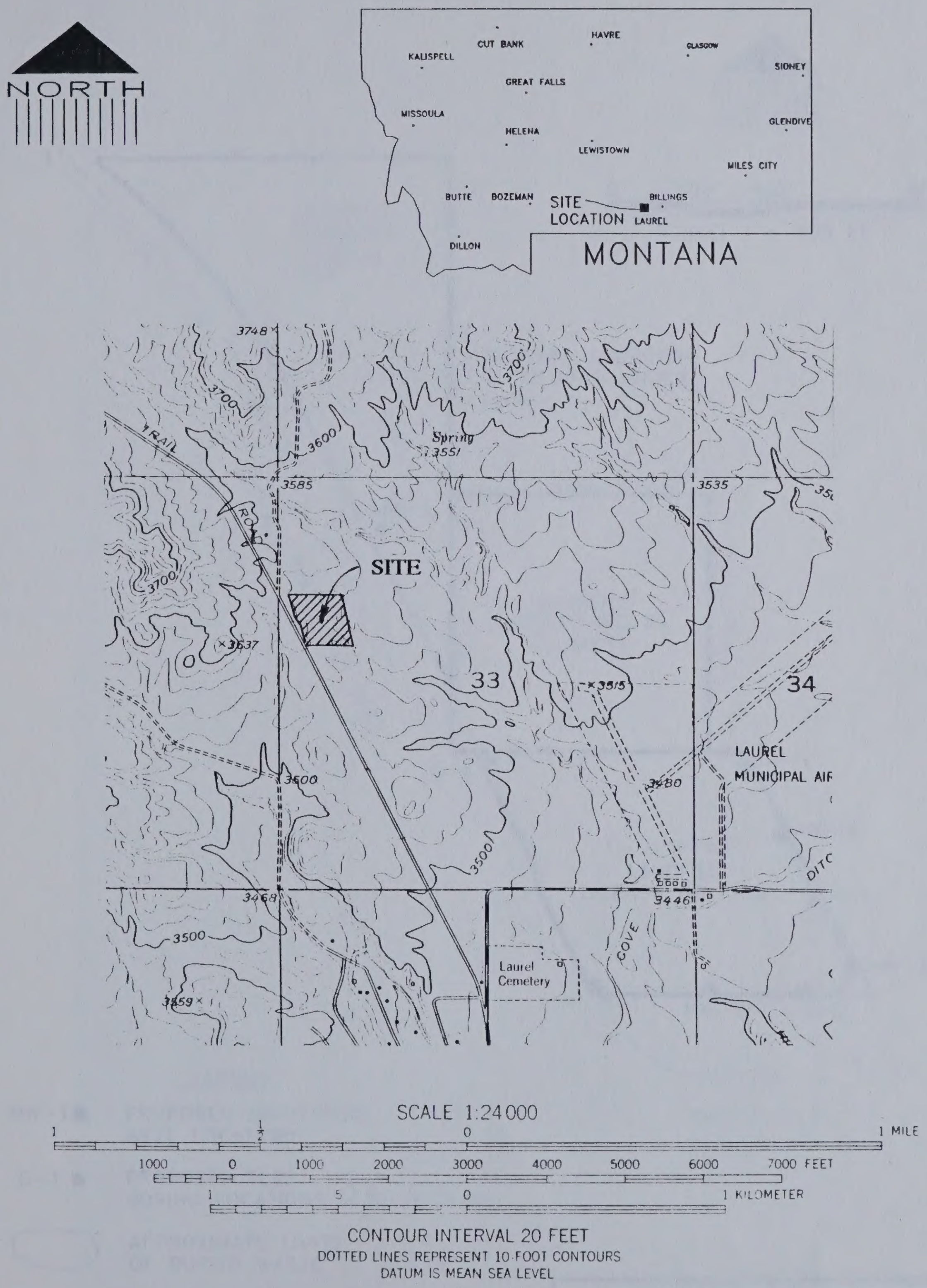
The site is located on colluvial uplands above the Yellowstone Valley. Prior to landfilling, the topography was gently sloping toward the southeast with shallow swales draining the central area of the site to a more defined swale which generally followed the east boundary and exited toward the southeast. The site is currently mostly covered with waste to the boundaries. A drainage swale which drains a significant area is located along the north and east boundaries of the older (#24) landfill. The older landfill has been graded to smooth, positively drained, gentle slopes with the highest points near the center. A final cover has been applied and vegetation has been established. The current site is less smooth and some concrete construction debris is uncovered. Soil borrow areas are located off the licensed facility to the west and north. A site plan showing the site features is presented on Figure 2-2.

contours for final cover?

Colorado Shale ?

The uppermost geological unit at the site is slopewash deposits consisting of silt and silty clay which were derived from erosion of nearby bedrock (Gosling and Pashley, 1973). This unit — ? is reported to yield small quantities of highly mineralized water. The slopewash deposits are underlain by Colorado Shale (Frontier Formation). Bedrock is expected to be between 50 — ? to 100 feet below ground surface. Based on nearby test borings, a gravel unit present in the Yellowstone Valley may be absent at the site (Hutchinson, 1983).

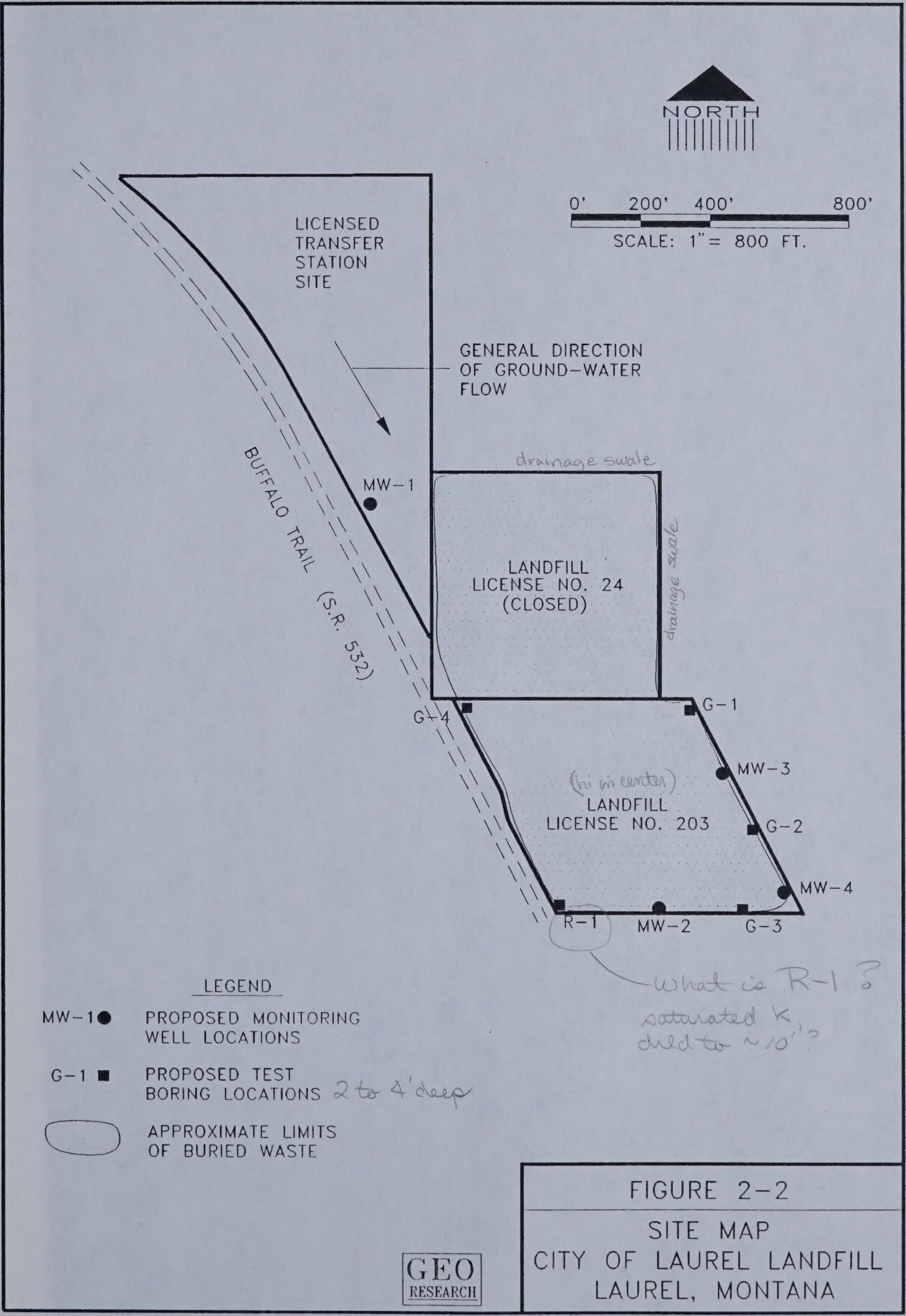
According to well logs on record at the Montana Bureau of Mines and Geology in Butte, very few wells are located within one mile north, east, and west of the site. Two wells ← ✗ (gas located north of the site encountered ground water at depths of less than 30 feet. Many wells are located south of the site including several in the Beartooth and Groshelle Heights subdivisions. These wells encountered ground water in gravel at depths ranging from 40 to 150 feet with most being between 80 and 110 feet deep. These wells are apparently completed in the gravel unit of the Yellowstone Valley. Based on the topography of the area, the general direction of ground water movement is expected to be southeast. This



GEO RESEARCH

FIGURE 2-1

VICINITY MAP
CITY OF LAUREL LANDFILL
LAUREL, MONTANA


NORTH
0'
200'
400'
800'
SCALE: 1" = 800 FT.
LICENSED TRANSFER STATION SITE
GENERAL DIRECTION OF GROUND-WATER FLOW
BUFFALO TRAIL (S.R. 532)
MW-1
drainage swale
drainage swale
LANDFILL LICENSE NO. 24 (CLOSED)
G-4
G-1
MW-3
(hi in center)
LANDFILL LICENSE NO. 203
G-2
MW-4
R-1
MW-2
G-3
LEGEND
MW-1 ● PROPOSED MONITORING WELL LOCATIONS
G-1 ■ PROPOSED TEST BORING LOCATIONS
APPROXIMATE LIMITS OF BURIED WASTE
GEO RESEARCH

What is R-1? saturated K, drld to ~10'?

2 to 4' deep

FIGURE 2-2

SITE MAP
CITY OF LAUREL LANDFILL
LAUREL, MONTANA

← ? max depth
← of drlg 150'
if in shale

concurs with the direction of flow in the gravel unit (Gosling and Pashley, 1973; Hutchinson, 1983). The nearest well to the southeast is located near the airport and encountered ground water at 60 feet in shale and gravel. Copies of driller's logs for selected nearby water wells are attached in Appendix A. North of the site, wells are completed in shallow gravel which is mapped as high terrace deposits by Gosling and Pashley (1973). The terrace deposits are not mapped at the site. No wells were reported to be completed in the shale bedrock.

On-site information indicates that some ground water seepage was detected during excavation of trenches. Additionally, the U.S.G.S. topographic map indicates that a spring is located north of the site. State regulations require monitoring of the uppermost aquifer at the site and if shallow seeps are encountered, these will be evaluated for flow rate. If the flow is greater than one gallon per minute, then the shallow water will become the target of the investigation. However, if no seeps are encountered, then the target ground water will be at the depth of the neighboring water wells. It is estimated that the depth to ground water on the site is on the order of 50 to 150 feet. Based on a geologic cross-section (Gosling and Pashley, 1973) the basal gravel thins to the north. It is possible that ground water may not be encountered in the slope wash or gravel units. Since the shale is not used as a source of drinking water in the area, ground water may be either absent in the shale or too highly mineralized for domestic use. The maximum depth of drilling at the site will be 150 feet, presumably within the shale. For the purposes of this work plan, it is assumed that the wells will be 100 feet deep.

recharge + discharge potential (amts)

deeper aquifer +/or confining layer

leachate attenuation capacity

CEC cation exchange capacity

elec. cond
(salinity)

? SAR
(
? Absorption
Ratio

(sorting)
Cementation

3.0 PROPOSED INVESTIGATION

3.1 Soil Investigation

According to §ARM 16.14.703, the ten acre site should be evaluated with a minimum of 15 test borings and backhoe test pits. However, the site is covered with waste essentially to the site boundaries. Figure 2-2 shows limits of waste within the property boundary. Drilling or digging through waste is not recommended due to the presence of potentially explosive and/or toxic landfill ~~gasses~~. ← Aquifer contamination Therefore, test borings will be drilled around the perimeter of the site only. A total of seven to nine test borings will be drilled or augered including four borings drilled to the uppermost aquifer. The remainder will be shallow soil borings. (3-5) All borings will be continuously logged for lithology during drilling or augering.

9 4 5   7 4 3

— in unsaturated zone +/or saturated zone ?, how many each

Selected soil samples collected from the borings will be laboratory tested for grain size distribution, total organic carbon, soil pH, moisture content, and/or density.

3.2 Ground-Water Investigation

In general, the hydrogeologic work at the site is required under the Montana Solid Waste Management Act §75.10.207(1) MCA and the content of investigation is defined under Title 16, Chapter 14, Subchapter 7, of the Administrative Rules of Montana (§16.14.701 through §16.14.717 ARM).

Ground water sample analytical parameters are specified under §16.14.706 ARM. Table 1 If no ground water contamination is detected during the initial monitoring well sampling, further investigation beyond required semi-annual resampling would likely not be required. However, if contamination is detected or the data are inconclusive, then additional investigation may be required which may include additional wells. According to §16.14.711 ARM, a minimum of six sampling events must be conducted as a part of landfill closure if the site is closed by January 1, 1993. However, this requirement may be modified at the discretion of the State. & if contam is found. If closure is not achieved by Jan 1, 1993 semi-annual sampling events will be required through the 30 yr → post closure period [see ARM 16.14.712(2)].

20'? +2

→The first two test borings (wells) will be drilled to a maximum depth of 150 feet. ← must encounter confining layer (i.e. shale) regionally extensive lateral extent Should no ground water be encountered, drilling will be terminated. The two test borings would be left open and temporarily covered at the surface to prevent surface seepage. The test borings would be checked a week daily for a later for ground-water seepage. At that time the Solid and Hazardous Waste Bureau (SHWB) Solid Waste Program would be contacted to confer on future drilling. Should no aquifer be encountered up to 150 feet below the site, a no migration petition would be submitted to the SHWB.

NO

Must demonstrate there is NO potential for leachate to contam the gdwtr. All 7 to 9 borings will be required! to at least 20' below bottom of existing waste for purposes of soils charac + possibly encountering perched aquifers

3.2.1 Number and Location of Monitoring Wells

Due to most of the site being covered with waste and the potential health risks associated with drilling through waste, + cross contam of lower zones from uphole wastes only four monitoring wells will be installed for ground-water sampling. One well will be located off site upgradient of the landfill and three monitoring

wells will be located downgradient along the perimeter of the property boundary. Figure 2-2 shows location of the proposed monitoring wells (MW-1 through MW-4).

3.2.2 Monitoring Well Installation and Construction

Monitoring wells will be installed using an air rotary drill rig. Equipment will be steam cleaned between each well installation & prior to use to prevent any potential cross-contamination between sites &/or boreholes. The upgradient well will be installed first to be followed by the downgradient wells. Wells will be installed under the supervision of a GeoResearch hydrogeologist who is also a licensed monitoring well constructor. All boreholes will be logged for lithology using Unified Soil Class? using drill cuttings.

Monitoring wells will be completed using two-inch diameter, flush threaded, Schedule 40, polyvinyl chloride (PVC) casing with 0.020-inch slotted screen how much (5, 10' or more?) and blank sections. Wells will be screened in the uppermost water bearing zone encountered during drilling. 10/20 8/12 ? mesh silica sand will be used to fill the annulus around the screen to a depth of approximately two feet above the screened interval. Wells will be sealed using bentonite chips on top of the sand and grout to the surface. A locking six-inch diameter steel surface casing will be installed over each well head. Each well will be marked clearly for identification including the ground-water measuring point. Figure 3-1 is a schematic showing typical monitoring well construction.

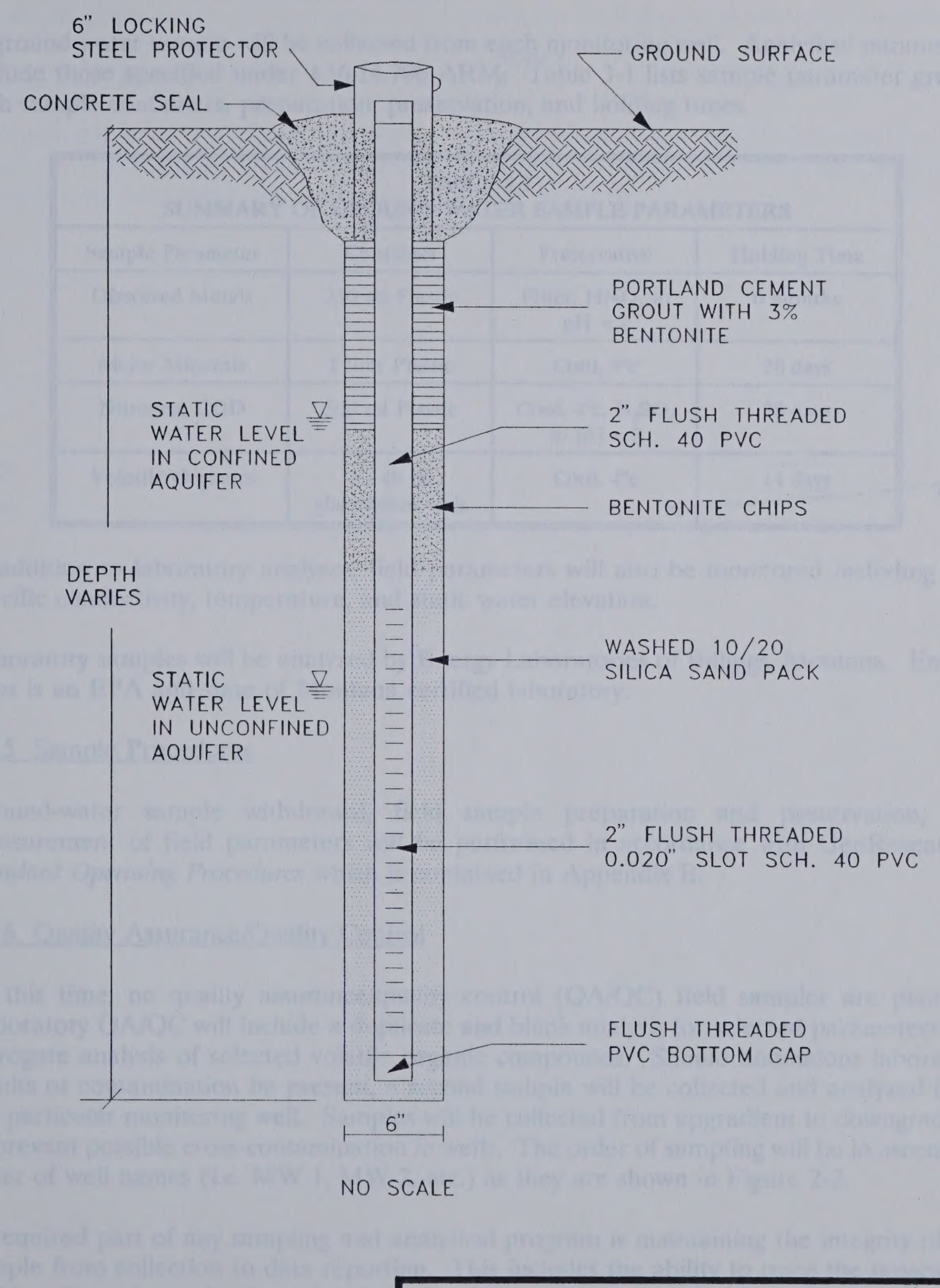
After completion of construction, wells will be developed using a mechanical bailer. Monitoring wells will be surveyed for horizontal location and vertical elevation.

3.2.3 Hydraulic Conductivity Testing

Slug tests will be performed on each monitoring well to determine transmissivity and hydraulic conductivity of the target aquifer. If the aquifer is confined, the data will be reduced using the method of Cooper et al. (1967). If the aquifer is unconfined, the Bouwer and Rice (1976) method will be used for data reduction.

In addition to slug tests, field-saturated hydraulic conductivity and matrix flux potential will be measured in the unsaturated zone using a Guelph permeameter and hand-augered test — info borings (Soilmoisture Equipment Corp. 1986). The shallow test borings will be located along the south and east property boundary and will be approximately two to four feet deep. Two to four sites (G-1 through G-4) will be selected to determine the total (horizontal plus — ? vertical) unsaturated hydraulic conductivity. A field saturated hydraulic conductivity test measured in the vertical direction will be conducted on a single test boring (R-1) at a depth of approximately ten feet (Reynolds and Elrick, 1990). This test boring will be drilled using the drill rig.

deep enough for water?
Constant head — in lab?, recompacted?



GEO
RESEARCH

FIGURE 3-1
TYPICAL MONITORING WELL
CONSTRUCTION

3.2.4 Ground-Water Monitoring Parameters

A ground-water sample will be collected from each monitoring well. Analytical parameters include those specified under §16.14.706 ARM Table 1. Table 3-1 lists sample parameter groups with sample containers, preparation, preservation, and holding times.

TABLE 3-1
SUMMARY OF GROUND-WATER SAMPLE PARAMETERS

Sample Parameter	Container	Preservative	Holding Time
Dissolved Metals	250 ml Plastic	Filter, HNO_3 to pH <2	6 months
Major Minerals	1 liter Plastic	Cool, 4°c	28 days
Nitrogen, COD	500 ml Plastic	Cool, 4°c, H_2SO_4 to pH <2	28 days
? Volatile Organics	2 - 40 ml glass/teflon vials	Cool, 4°c	14 days

No preservative?

In addition to laboratory analyses, field parameters will also be monitored including pH, specific conductivity, temperature, and static water elevation.

Laboratory samples will be analyzed by Energy Laboratories of Billings, Montana. Energy Labs is an EPA and state of Montana certified laboratory.

3.2.5 Sample Procedures

Ground-water sample withdrawal, field sample preparation and preservation, and measurement of field parameters will be performed in accordance with GeoResearch's *Standard Operating Procedures* which is contained in Appendix B.

serve as a SAP prelim.

3.2.6 Quality Assurance/Quality Control

At this time, no quality assurance/quality control (QA/QC) field samples are planned. Laboratory QA/QC will include a duplicate and blank analysis for selected parameters and surrogate analysis of selected volatile organic compounds. Should anomalous laboratory results or contamination be present, a second sample will be collected and analyzed from the particular monitoring well. Samples will be collected from upgradient to downgradient to prevent possible cross-contamination in wells. The order of sampling will be in ascending order of well names (i.e. MW-1, MW-2, etc.) as they are shown in Figure 2-2.

dup. a well don't wait for abnormalities 706(1)(b)(i)(c)(H)

A required part of any sampling and analytical program is maintaining the integrity of the sample from collection to data reporting. This includes the ability to trace the possession and handling of samples from the time of collection, through analysis, and final disposition.

The documentation of the sample's history is referred to as the "chain of custody". Chain of custody procedures will be conducted as stated in the *Standard Operating Procedures.*

3.2.7 Data Validation

Laboratory data results will be checked for reasonableness. Data entry will be checked and verified for correctness. Further statistical analysis can be performed when additional data are collected during the ground-water monitoring program.

4.0 REPORT AND RECOMMENDATIONS

Upon completion of the hydrogeological and soils field investigation a summary report will be prepared summarizing work performed and laboratory results. Information which will be included in the report are aquifer characteristics, ground-water flow direction, soil engineering properties, and ground-water quality.

simultaneously

Recommendations will be made for development of a ground-water monitoring plan. Should initial ground-water sample results indicate no contamination, the required minimum six samplings would be recommended for the site. If contamination is detected, a more detailed work plan may be developed including installation of additional monitoring wells.

Cross sections
Potentiometric map
lateral extent of aquifer (gravels?) map
man-made influences - wells, etc; locate on topo map

REFERENCES

Bouwer, H., and Rice, R.C., 1976, A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells; Water Resources Research v.12 n.3 pp.423-428.

Cooper, H.H., Bredehoeft, J.D., and Papadopulos, I.S., 1967, Response of a Finite-Diameter Well to and Instantaneous Charge of Water; Water Resources Research, v.3, n.1, pp. 263-269.

Gosling, Arthur W., and Pashley, Jr., Emil F., 1973, Water Resources of the Yellowstone River Valley, Billings to Park City, Montana; Hydrologic Investigations Atlas HA-454, U.S. Geological Survey, Washington D.C. map

Hutchinson. R.D., 1983, Changes in the Shallow Ground Water Resources near Billings, August 1968-1978, Yellowstone River Valley, South-Central Montana; Montana Bureau of Mines and Geology Hydrogeologic Map 6 map

Reynolds, W.D., and Elrick, D.E., 1990, Ponded Infiltration from a Single Ring: I. Analysis of Steady Flow; Soil Science Society of America Journal v.54, n.5, pp. 1233-1241.

Soilmoisture Equipment Corp., 1986, Operating Instructions for Model 2800KI Guelph Permeameter; Soilmoisture Equipment Corp. Santa Barbara, CA

APPENDIX A

NEARBY WATER WELL LOGS

111 02S 24E 04 BCD

ORM No: 603 New 7-73

RECEIVED
NOV 22 1974
Bureau of

Yellowstone

ot 21 BEARTOOTH SUB. D.

File No. 3702-943Q

25-24E-4

STATE OF MONTANA
Department of Natural Resources and Conservation

WHITE — DEPARTMENT
PINK — BUREAU
CANA
GOLD

017988

WELL LOG REPORT

State law requires that this form be filed by the water well driller on any water well completed by him on and after July 1, 1973 within sixty (60) days after completion of the well.

1. WELL OWNER: Name LARRY T. DIEDE Address 320½ DURLAND DR. LAUREL, MT

2. WELL LOCATION: County YELLOWSTONE ; SE¼SW¼NW¼, Sec. 4 , Twp. 2 N [✓ S] Rg. 24 [✓ E] W

3. PROPOSED USE: ✓ Domestic ___ Stock ___ Municipal ___ Industrial ___ Lawn and Garden
___ Irrigation ___ Other (*if other, specify*) ___

4. METHOD DRILLED: ___ Cable ___ Bored
✓ Forward Rotary ___ Reverse Rotary
___ Jetted ___ Other (*if other, specify*)

5. WELL CONSTRUCTION:
Diameter of hole 8 inches. Depth 110 ft.
Casing: ✓ Steel ___ Plastic ___ Concrete
___ Threaded ✓ Welded ___ Other (*if other, specify*) ___
Pipe Weight: Dia.: From: To:
20 lb/ft. 7 inches 1+ feet 110 feet
___ lb/ft. ___ inches ___ feet ___ feet
___ lb/ft. ___ inches ___ feet ___ feet
Was perforated pipe used? ✓ Yes ___ No
Length of pipe perforated 22 feet
Was casing left open end? ✓ Yes ___ No
Was a well screen installed? ___ Yes ___ No
Material ___ Dia. ___ inches
(*stainless steel, bronze, etc.*)
Perforation type: ✓ slots ___ holes
Size 1/8 set from 88 feet to 110 feet
Size / set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Was a packer or seal used? ✓ Yes ___ No
If so, what material Butyl
Well type: ___ Straight screen ✓ Graveled
Was the well grouted? ✓ Yes ___ No
To what depth? 8 feet
Material used in grouting Cement
Well head completion: Pitless adapter
12" above grade ✓ Other ___
(*If other, specify*) ___
Was the well disinfected? ___ Yes ✓ No

6. WATER LEVEL:
Static water level 90 ft. below land surface
If flowing: closed-in pressure ___ psi
GPM flow ___ through ___ inch pipe
Controlled by: ___ Valve ___ Reducers
___ Other, specify ___

7. WELL TEST DATA: ___ Pump ✓ Bailer ___ Other
(*If other, specify*) ___
Pumping level below land surface:
95 ft. after 2 hrs. pumping 15 gpm
___ ft. after ___ hrs. pumping ___ gpm

8. WELL LOG:

Depth (ft.) From	Depth (ft.) To	Formation
0	40	SANDY TOP SOIL
40	90	SAND
90	105	GRAVEL
105	110	BLUE SHALE

(*Use separate sheet if necessary*)

9. DATE STARTED: 6/29/74

10. DATE COMPLETED: 8-19-74

11. WAS WELL PLUGGED OR ABANDONED? ___ Yes ✓ No
If so, how /

12. DRILLER'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

DIGGER DRILLING 197
Driller's or Firm Name *License No.*

3143 PRAIRIE DR. BILLINGS, MT 59101
Address

J. J. Bas 8-21-74
Signed by *Date*

02S 24E 04

-M+

Form No. 603 R9/82 YELLOWSTONE

File No. ____

016125

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completi

1. WELL OWNER
Name Bob Auer

2. CURRENT MAILING ADDRESS
2927 Beech Ave
Billings, Montana

3. WELL LOCATION
County Yellowstone
Township 2S N/S Range 24E E/W
NW¼ ¼ ¼ ¼ Section 4
Lot 5 Block 1-2-3 Amend
Subdivision Groshell Sub

4. PROPOSED USE Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify ____

5. DRILLING METHOD ____ cable, ____ bored,
X forward rotary, ____ reverse rotary, ____ jetted,
____ other (specify) ____

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations and/or Screen: Kind Size	From (feet)	To (feet)
7⅞"	6⅝" steel .250	0'	27'	Surface Pipe		
6"	5" OD PVC 160#	27'	112'	⅛ slot	106'	112'

Was casing left open end? X Yes ____ No
Was a packer or seal used? X Yes ____ No
If so, what material Bentonite
Was the well gravel packed? ____ Yes X No
Was the well grouted? X Yes ____ No
To what depth? 27'
Material used in grouting Bentonite
Well head completion: Pitless adapter
____ Yes ____ No
Top of casing 12 in. or greater above grade
X Yes ____ No

7. WHAT IS THE TEMPERATURE OF THE WATER?
____ Degrees Fahrenheit
☐ Measured ☐ Estimated

8. WATER LEVEL
Static water level 82' feet below land surface
If flowing; closed-in pressure ____ psi
____ gpm
Controlled by: ____ valve, ____ reducers,
____ other, (specify) ____

9. WELL TEST DATA X pump ____ bailer
____ other, (specify) ____
Pumping level below land surface:
108 ft. after 2 hrs. pumping 12' gpm
____ ft. after ____ hrs. pumping ____ gpm

10. WAS WELL PLUGGED OR ABANDONED? ____ Yes X No
If yes, how? ____

11. DATE COMPLETED 9-15-83

12. WELL LOG

Depth (ft.) From	To	Formation
0'	27'	Brown clay-gravel
27'	101'	Brown sticky clay
101'	112'	gravel sand

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
Date 9-26-83
Firm Name Billings Drilling
Address 14023 Roundup Rd, Blgs
Signature LaVern Jewett License No. 264#

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION **DNRC**

32 SOUTH EWING HELENA, MONTANA 59620 449-3962

DEPARTMENT — BUREAU COPY

111 Yellowstone

Form No. 603 R9/82

File No.__________

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after comple 016126

1. WELL OWNER
Name Bernard Coisen

2. CURRENT MAILING ADDRESS
11st + word Ave
Red Lodge MT 59068

3. WELL LOCATION
County Yellowstone
Township 2 N/S Range 24 [✓ E]/W
Tract 1/4 1/4 NW 1/4 Section 4
~~Lot~~ 1 Block
Subdivision Beartooth sub.

4. PROPOSED USE Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify

5. DRILLING METHOD X cable, ___ bored, ___ forward rotary, ___ reverse rotary, ___ jetted, ___ other (specify)

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)
6	6"-17#	0	41½

Perforations None and/or Screen None

Kind Size	From (feet)	To (feet)

Was casing left open end? X Yes ___ No
Was a packer or seal used? ___ Yes X No
If so, what material
Was the well gravel packed? ___ Yes X No
Was the well grouted? ___ Yes X No
To what depth?
Material used in grouting
Well head completion: Pitless adapter ___ Yes ___ No
Top of casing 12 in. or greater above grade X Yes ___ No

7. WHAT IS THE TEMPERATURE OF THE WATER?
50 Degrees Fahrenheit
☐ Measured ☒ Estimated

8. WATER LEVEL
Static water level 22' feet below land surface
If flowing; closed-in pressure ___ psi
___ gpm
Controlled by: ___ valve, ___ reducers, ___ other, (specify)

9. WELL TEST DATA ___ pump X bailer ___ other, (specify)
Pumping level below land surface:
26 ft. after 1/2 hrs. pumping 25 gpm
___ ft. after ___ hrs. pumping ___ gpm

10. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If yes, how?

11. DATE COMPLETED 11-15-83

12. WELL LOG

Depth (ft.) From	To	Formation
0	1	Top Soil + Rock
1	6	Sand Gravel + Clay
6	23	Sandy Clay
23	33	Clay
33	35	Sandy Clay
35	38	Sand
38	41½	Sand + Gravel

RECEIVED
MAR - 5 1984
DEPT. OF NATURAL RESOURCES
AND CONSERVATION
BILLINGS OFFICE

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
11-19-83
Date
KAL Well Service
Firm Name
209 6th Ave, Laurel MT 59044
Address
Kenneth M. Bever 435
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION **DNRC**

32 SOUTH EWING HELENA, MONTANA 59620 449-3962

DEPARTMENT — BUREAU COPY

111 02S 24E 04 B YELLOWSTONE

rm No. 603 (Rev. 3/75)

File No. 16903-943Q

STATE OF MONTANA
Department of Natural Resources and Conservation

White-Department
Pink-Bureau
Yellow-Well owner
Gold-Driller

WELL LOG REPORT

Coded

017984

State law requires that this form be filed by the water well driller withi completion of the well, and Form 602, Notice of Completion of Groundwater [illegible] filed by the well owner within 60 days after the water has been put to beneficial use.

WELL OWNER Name Rudy Greshelle ~~Leonard & Betty Lamb~~ Current address LAUREL MONTANA

WELL LOCATION Lot 3, Block 1-2-3 Amended Subdivision Greshelle Heights
County YELLOWSTONE, or NW ¼ ____ ¼ ____ ¼ Sec. 4, T. 2 S, R. 24 E

PROPOSED USE X domestic (includes lawn and garden); ____ stock; ____ municipal; ____ industrial; ____ irrigation; ____ other (specify) ____

METHOD DRILLED ____ cable, ____ bored, X forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify) ____

WELL CONSTRUCTION
Diameter of hole 7⅞" in.; depth 102' ft.
Casing: ____ steel, ____ plastic, X concrete, ____ threaded, ____ welded, ____ other (specify) ____

Pipe weight: Plastic Dia. 5" From 0 To 102'

____ lb/ft ____ in. ____ ft. ____ ft.
____ lb/ft ____ in. ____ ft. ____ ft.

Was casing left open end? X Yes ____ No
Was a well screen installed? ____ Yes X No
Material ____, dia. ____ in.
(stainless steel, bronze, etc.)
Was perforated pipe used? X Yes ____ No
Perforation type: X slots ____ holes
Size ⅛" set from 98 ft. to 102 ft.
Size ____ set from ____ ft. to ____ ft.
Was a packer or seal used? X Yes ____ No
If so, what material Rubber & cement
Well type: ____ Straight screen ____ Graveled
Was the well grouted: ____ Yes X No
To what depth: — ft.
Material used in grouting —
Well head completion: Pitless adapter X
12 in. above grade X, other ____
(if other, specify) ____
Was well disinfected? X Yes ____ No

6. WATER LEVEL
Static water level 50 ft. below land surface
If flowing: closed-in pressure ____ psi
gpm flow ____ through ____ inch pipe
Controlled by: ____ valve ____ reducers
____ other (specify) ____

7. WELL TEST DATA ____ Pump X Bailer ____ Other
(if other, specify) ____
Pumping level below land surface:
80 ft. after 1 hrs. pumping 15 gpm
____ ft. after ____ hrs. pumping ____ gpm

8. WELL LOG

Depth (ft) From	Depth (ft) To	Formation
0	10'	SOIL
10	25'	MIXED GRAVEL-DIRT & YELLOW CLAY
25	70'	CLAY & SHALE LAMINATED
70	98'	GRAVEL & BOULDERS
98	102'	PEA GRAVEL & SAND

(use separate sheet if necessary)

9. DATE STARTED July 15 - 1975
DATE COMPLETED July 16 - 1975

10. WAS WELL PLUGGED OR ABANDONED? ____ Yes X No
If so, how? ____

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Roy R. Reid 170
Driller's or firm name License No.

Billings Mont.
Address

Roy R. Reid 8/15/75
Signed by date

File No. 111 02S 24E 04Bc

TRIPLICATE Yellowstone

RECEIVED
NOV 15 1968
Montana Bureau of
Mines and Geology

(1)

T2 South R24 East 4

County Yellowstone

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER
OFFICE OF STATE ENGINEER

017987

Notice of Completion of Groundwater Appropriation by Means of Well

(Under Chapter 237, Montana Session Laws, 1961)

Top of Ground
(Elev. above sea level 3385)

40' Dirt & Gravel

67' Yellow Clay

5' Sand & Gravel
112.5'

Owner Beartooth Enterprises, Inc. Address Box 18, Laurel, Mont.

Driller Beartooth Enterprises, Inc. Address Box 18, Laurel, Mont.

Date of Notice of Appropriation of Groundwater

Date well started 9-4-68 Date Completed 10-11-68

Type of well Drilled (dug, driven, bored or drilled) Equipment Used Drill (Churn, drill, rotary or other)

Water Use: Domestic ☒ Municipal ☐ Other ☐ Irrigation ☐ Industrial ☐ Drainage ☐ Stock ☐

☞ Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS		
				Kind Size	From (Feet)	To (Feet)
6"	6" 19 lb. .280	0	112.5	None		

Static Water Level for non-flowing Well 20.5 feet.

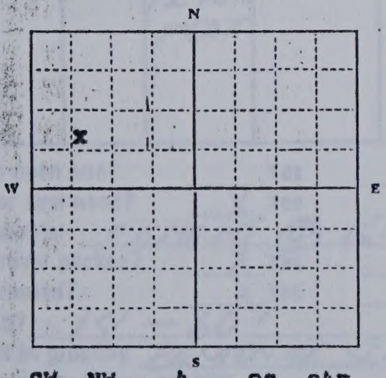
Shut-in Pressure for Flowing Well

Pumping Water Level 92 feet at 10 gal. per minute.

Discharge in gal. per min. of flowing well

How Tested Bailer Length of Test 1 hour

Remarks: (Gravel packing, cementing, packers, type of shutoff, location of place of use of groundwater if not at well, and any other similar pertinent information, including number of acres irrigated, if used for irrigation) None used.



SW ¼NW Sec. 4 T. 2S R. 24E

Indicate location of well and place of use, if possible. Each small square represents 10 acres.

Show exact depth of bottom.

Robert P. Rossett
Driller's License Number

Beartooth Enterprises, Inc.
Driller's Signature

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located.

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

Original to the County Clerk and Recorder; duplicate to the State Engineer; Triplicate to the Montana Bureau of Mines and Geology and Quadruplicate for the Appropriator.

Billings Yellowstone

Form No. 603 (R 6-84)

File No. 057728

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name FRANK FELKE

2. CURRENT MAILING ADDRESS
4417 HARVEST LANE
BILLINGS, MT 59106

3. WELL LOCATION
County YELLOWSTONE
Township 1 [✓ N]/S Range 24 [✓ E]/W
1/4 E1/2 SE1/4 Section 33
Lot Block
Subdivision LAUREL AIRPORT

4. PROPOSED USE Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify

5. DRILLING METHOD ___ cable, ___ bored,
X forward rotary, ___ reverse rotary, ___ jetted,
___ other (specify)

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations 1/4 INCH and/or Screen Kind Size	From (feet)	To (feet)
7 7/8"	6 5/8" 1/4 WALL STEEL	0'	15'			
7 7/8"	6" PVC 160PSI	15'	98'	1/4" HOLES 12 PER FOOT	60'	98'

Was casing left open end? ___ Yes X No
Was a packer or seal used? X Yes ___ No
If so, what material CEMENT @ 15'-SURFACE
Was the well gravel packed? X Yes ___ No
Was the well grouted? X Yes ___ No
To what depth? 15' - 60'
Material used in grouting BENTONITE SLURRY
Well head completion: Pitless adapter X Yes ___ No
Top of casing 12 in. or greater above grade X Yes ___ No

7. WHAT IS THE TEMPERATURE OF THE WATER?
45° Degrees Fahrenheit
☐ Measured ☒ Estimated

8. WATER LEVEL
Static water level 48' feet below land surface
If flowing; closed-in pressure ___ psi
___ gpm
Controlled by: ___ valve, ___ reducers,
___ other, (specify)

9. WELL TEST DATA ___ pump ___ bailer
___ other, (specify) AIR PUMP
Pumping water level below land surface:
60 ft. after 1 hrs. pumping 40 gpm
60 ft. after 2 1/2 hrs. pumping 40 gpm

10. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If yes, how?

11. DATE COMPLETED

12. WELL LOG

Depth (ft.) From	To	Formation
0'	30'	SOIL, SHALE GRAVEL
30'	90'	ALTERNATING SHALE AND GRAVEL, VERY LITTLE SAND

RECEIVED
SEP 25 1986
DEPT. OF NATURAL RESOURCES
AND CONSERVATION
BILLINGS OFFICE

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
Date 9-1-86
Firm Name SWEETWATER DRLG & EXPLORATION
Address BOX 123, BILLINGS, MT 59103
Signature Tod H Williams
License No. 468

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59620 444-6610

STATE PUBLISHING CO., HELENA, MONT.

DEPARTMENT - BUREAU COPY

111 1S 24E 34 CB Yellowstone

Form No. 603 (R 6-84)

File No.

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion 015734

1. WELL OWNER
Name MIKE VISSER

2. CURRENT MAILING ADDRESS
MR MIKE VISSER
RAPELJE, MT 59067

3. WELL LOCATION
County YELLOWSTONE
Township 1 N/[✓ S] Range 24 [✓ E]/W
¼ ¼ Section ~~33~~ 34
Lot NW SW Block
Subdivision ADJACENT TO VISSER HANGER

4. PROPOSED USE Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify CROP DUSTING SUPPLY

5. DRILLING METHOD ___ cable, ___ bored,
X forward rotary, ___ reverse rotary, ___ jetted,
___ other (specify)

6. WELL CONSTRUCTION AND COMPLETION

Perforations 1/8 INCH and/or Screen

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Kind Size	From (feet)	To (feet)
8¾"	6⅝" ¼ WALL STEEL	0'	15'	1/8" 12 PER FOOT	76'	110'
8¾"	6⅝" 160 PSI PVC	15'	110'			

Was casing left open end? ___ Yes X No
Was a packer or seal used? X Yes ___ No
If so, what material CEMENT @ 15'
Was the well gravel packed? X Yes ___ No
Was the well grouted? X Yes ___ No
To what depth? 15'
Material used in grouting BENTONITE SLURRY
Well head completion: Pitless adapter X Yes ___ No
Top of casing 12 in. or greater above grade X Yes ___ No

7. WHAT IS THE TEMPERATURE OF THE WATER?
45° Degrees Fahrenheit
☐ Measured ☒ Estimated

8. WATER LEVEL
Static water level 70' feet below land surface
If flowing; closed-in pressure ___ psi
___ gpm
Controlled by: ___ valve, ___ reducers,
___ other, (specify)

9. WELL TEST DATA ___ pump ___ bailer
___ other, (specify) AIR PUMP
Pumping water level below land surface:
80 ft. after 2 hrs. pumping 35 gpm
80 ft. after 4 hrs. pumping 35 gpm

10. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If yes, how?

11. DATE COMPLETED

12. WELL LOG

From	To	Formation
0'	30'	SOIL, SHALE, GRAVEL
30'	70'	SHALE, CLAY
70'	110'	SAND, GRAVEL, CLAY

RECEIVED
MAR 18 1986
DEPT. OF NATURAL RESOURCES AND CONSERVATION
BILLINGS OFFICE
HD

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Date 3/18/86
Firm Name SWEETWATER DRLG. & EXPLORATION INC.
Address P.O. BOX 123 BILLINGS, MT
Signature Ted H. Williams License No. 468

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION **DNRC**
32 SOUTH EWING HELENA, MONTANA 59620 444-6610

STATE PUBLISHING CO., HELENA, MONT.

DEPARTMENT - BUREAU COPY

M: 9227

Billings 111 1S 24E 34 CDD Yellowstone

Form No. 603 (R 6-87)

File No. ______

WELL LOG REPORT

022263

State law requires that this form be filed by the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name Harvey E AND Melody E Fox

2. CURRENT MAILING ADDRESS
8325 Airport Rd.
Laurel, Mt. 59044

3. WELL LOCATION
County Yellowstone
Township 1 [✓ S] Range 24 [✓ E] W
SE ¼ SE SW ¼ Section 34
Lot ______ Block
Subdivision ______
Tract Number ______

4. PROPOSED USE Domestic ☐ Stock ☑ Irrigation ☐
Other ☐ specify ______

5. DRILLING METHOD ✓ cable, ______ air rotary, ______ forward rotary, ______ reverse rotary, ______ jetted, ______ other (specify) ______

Depth (ft.) From	To	Formation
0	5	Gravel + SAND
5	45	SAND with som Brn Clays
45	67	Clay With sand Stringers
67	74	SAND Med fine (Water Bearing)
74	82	SAND + Gravel

ATTACH ADDITIONAL SHEETS IF NECESSARY

7. WELL CONSTRUCTION AND COMPLETION

Perforations ~~[illegible]~~ and/or Screen None

Size of drilled hole	Size and PSI Rating of casing	From (feet)	To (feet)	Kind Size	From (feet)	To (feet)
6"	6"	12	82			
	inserted liner 4½" PVC	20	82	10 ft factory sloted casing from 72 to 82 ft		

Was casing left open end? ✓ Yes ______ No
Was a packer or seal used? ______ Yes ✓ No
If so, what material ______
Was the well gravel packed? ______ Yes ✓ No
To what depth was the well grouted? 82 ft
Material used in grouting Bentonite
[illegible] Pitless adapter ______ Yes ______ No
Top casing 18 in. or greater above grade ✓ Yes ______ No

8. WELL TEST DATA

The pump test information request in this section is required for all wells. All depth measurements shall be from the top of the well casing unless otherwise specified.

All wells under 100 gpm must be tested for a minimum of one hour and provide the following information:

a) Air ______ Pump ✓ Bailer ______
b) Static water level immediately before testing 40 ft. If flowing; closed-in pressure ______ psi ______ gpm
Controlled by: ______ valve, ______ reducers, ______ other, (specify) ______
c) Depth at which pump is set for test 78
d) The pumping rate and means of discharge (i.e., bailing, airlift, pumping) 50 gpm
e) Maximum drawdown during the test 50 ft
f) Duration of test: Pumping time 3 hrs
Recovery time 2 hrs
g) Recovery water level 40 ft
Amount of time after pumping recovery level water data was taken 2 hrs

Wells intended to yield 100 gpm or more shall be tested for a period of 8 hours or more. The test shall follow the development of the well, and shall be conducted continuously at a constant discharge at least as great as the intended appropriation. In addition to the above information, water level data shall be collected and recorded on the Department's "Aquifer Test Data" form included in each packet of well logs.

NOTE: All wells shall be equipped with an access port ½ inch minimum or a pressure gauge that will indicate the shut-in pressure of a flowing well. Removable caps are acceptable as access ports.

9. WAS WELL PLUGGED OR ABANDONED? ______ Yes ✓ No
If yes, how? ______

10. DATE COMPLETED 11-12-87

11. DRILLER/CONTRACTOR'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

11-18-87
Date

KAK Well Service
Firm Name

209 6th Ave. Laurel, MT. 59044
Address

Kenneth M. Bauer
Signature

435
License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION

1520 EAST SIXTH AVENUE HELENA, MONTANA 59620-2301 444-6610

DNRC

DEPARTMENT — BUREAU COPY

APPENDIX B

GEORESEARCH STANDARD OPERATING PROCEDURES

GeoResearch, Inc.

Standard Operating Procedures for Ground-Water Sampling at Municipal Landfills

September 4, 1992

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1.0 INTRODUCTION

This Standard Operating Procedures (SOP) Document details guidelines for ground-water sample collection at municipal landfills.

Sampling and testing methods discussed herein are accepted practices as referenced in the RCRA Ground Water Monitoring Technical Enforcement Guidance Document (National Water Well Association, 1986); Test Methods for Evaluating Solid Waste - Physical/Chemical Methods (SW-846, 1986); Methods for Chemical Analysis of Water and Wastes (EPA-600/4-79-020); and Standard Methods for the Examination of Water and Wastewater (1985).

Appropriate analytical parameters will be chosen prior to and consistent with the desired objectives of the specific sampling event.

2.0 GROUND-WATER SAMPLE COLLECTION

The primary goal of ground-water quality sampling is collection of representative ground-water samples for laboratory analysis. The materials and procedures described herein are designed to obtain representative ground-water samples from the aquifer(s) beneath a site.

2.1 Preparation and Mobilization

Equipment necessary to complete ground-water sampling for organics and inorganics are presented in Checklist 1.

2.2 Measurement of Static Ground-Water Elevation

Depth to ground water should be taken in all monitoring wells prior to sampling to determine static ground-water elevations. Ground-water elevation data are used to establish both horizontal and vertical ground-water flow gradients. ?

decon prior to + between wells

Depth to ground water can be determined using a well probe. The probe emits a signal when in contact with water. All measurements should be made to the nearest 1/100th of a foot and taken from the established point of reference on the well opening.

A record of previous depth to water measurements of each well should be checked to ensure the current measurement is reasonable. If not, a second measurement should be made to verify deviations from past sampling events. When previous water level data is lacking, all measurements should be taken twice to ensure accuracy. Depth to water measurements should be recorded in a weatherproof field notebook with other field parameter data.

CHECKLIST 1
Ground-Water Sampling Gear

___ High capacity peristaltic pump with polyethylene or polypropylene tubing or hand lift pump or mechanical bailer;

___ Stainless steel bailer for organic constituents and PVC bailer and polypropylene line for inorganic constituents;

___ Filtration unit and filters; size 45 micron

___ Probes/meters for temperature (degrees C), pH, and specific conductance, and spare batteries;

___ Standard pH calibration fluids (4, 7 and 10); and specific conductance calibration fluids (1000, 2000 and 10,000 umhos/cm);

___ Electronic well probe, with spare batteries;

___ Decontamination materials (phosphate-free Liquinox detergent; 10% nitric acid; distilled water; and brushes/bowls/paper towels); methanol & hexane

___ Engineer's measuring tape in 1/10ths;

___ Waterproof field sampling notebook and waterproof marking pen;

___ Measuring bucket (5 gallons);

___ Disposable gloves (PVC, polyethylene and inner vinyl);

___ Personal safety gear: hard hat, safety glasses, long sleeve shirt, steel toe boots, and Tyvek coveralls;

___ Cooler with ice;

___ Appropriate sample jars and bottles;

___ Field Data/Chain of Custody Sheets;

___ Well logs for wells to be sampled.

2.3 Well Evacuation

The goal of ground-water sampling is collection of water samples from monitoring wells which are representative of ground water contained within the aquifer. Standing water contained within the well casing undergoes physico-chemical changes which affect the validity of the sample. To obtain a representative sample, the stagnant casing water should be removed prior to sample collection.

Two accepted techniques are available to ensure that the ground-water sample collected represents formation water and not stagnant casing water. These techniques include:

which one at Lowell ?

- Evacuate a prescribed number of well casing volume;
- Evacuate water from wells until pH, specific conductance, and temperature, stabilize.

Casing volume removal is described in section 2.3.1 and field parameter stabilization in section 2.3.2.

2.3.1 Well Casing Volume Removal

To assure that a representative ground-water sample is obtained for chemical analysis, standing water in the well casing is removed prior to sampling. The volume of standing water contained inside the well casing is referred to as a well casing volume. The number of gallons per well casing volume must be calculated for each well to determine the volume of water to be evacuated prior to sampling. The number of gallons per well casing volume depends upon the casing diameter, depth of well, and the depth to water. The following formula is used to determine the volume of each well casing:

$$\text{Well Casing Volume (in gallons)} = 1/25 \times h \times (\text{dia})^2$$

?

Where:

dia = diameter of well in inches
h = column of water in feet
(depth of the well minus depth to water)

For Examples:

Let dia = 2 inch
h = 10 feet

$$\underline{\text{Well Casing Volume}} = (2)^2 \times (10) \times 0.04$$
$$= 1.60 \text{ gallons}$$

check this

The rate of removal and volume to be removed is dependent upon the depth to water, the ability of the aquifer to transmit water and the rate of recovery of the well. Evacuation of the casing volume should be at a rate which prevents ground water from cascading into the well casing. Cascading water should be avoided due to potential changes in volatile organic compound concentration caused by the turbulent inflow to the well casing.

2.3.2 Field Parameter Stabilization

Field parameter stabilization is an indicator of fresh formation water and is an accepted method for establishing adequate well evacuation. Stabilization is achieved when three consecutive specific conductance values are within 10% of each other and pH readings have stabilized to within 0.1 unit of each other.

Specific conductance, temperature, pH, and volume of water evacuated should be monitored and recorded every five minutes during well evacuation to assure stabilization of these parameters. In most cases, a minimum of two well casing volumes of water must be removed prior to sufficient stabilization of field parameters.

2.4 Sample Withdrawal for Organic Constituents

This section describes protocol for proper collection of ground-water samples for organic constituents.

Upon stabilization of field parameters or adequate well casing volume evacuation, ground-water sample collection is initiated.

Prior to sampling for organics, the stainless steel bailer must be decontaminated to prevent cross contamination. The following cleaning method is recommended for any equipment that is in contact with the ground water via the peristaltic pump or bailer:

- Wash with phosphate-free detergent solution (Liquinox)
- Rinse with distilled water

The bailer should be lowered slowly, not dropped, into the well as unnecessary agitation or aeration may alter the chemistry of the sample. Only single strand teflon coated stainless steel wire or polypropylene line may be used to lower the bailer into the well. The first three bails evacuated should be discarded to ensure removal of residues from the bailer. Care should be taken to minimize aeration and agitation when collecting organic samples. The sample should be poured down the side of the sample bottle and not splashed into its base.

In an effort to minimize cross-contamination, wells should be sampled in the order of least contaminated to most contaminated. Analytical results from previous sampling events can be used to determine the order of wells to be sampled.

2.5 Sample Withdrawal for Inorganic Metals

Collection of inorganic samples should be performed after organic sample collection. A PVC bailer is used for inorganic sample collection. The bailer should be decontaminated prior to use by rinsing with 10% nitric acid followed by a distilled water rinse. A polypropylene line may be used to lower the bailer into the well. The first three bails should be discarded to ensure removal of residues from the bailer. Sample water may be poured directly into the sample containers or into a sample collection container which has been decontaminated in the same manner as mentioned above.

Containers should be prepared in lab. Preservatives not preadded

2.6 Field Filtration Protocol

Field filtration of ground-water samples is required to obtain dissolved metals values as opposed to total metals values. Filtering should be performed on-site to ensure more accurate results and alleviate the need to rush samples to the laboratory within one hour of collection.

24?

Several field filtering devices are available, GRI uses a standard glass vacuum filtration system. This system has proven to be versatile, easy to use, and easy to decontaminate. Proper decontamination should include rinsing all pieces of the filtration system with 10% nitric acid followed by a distilled water rinse.

Assemble the filtration system using a 0.45 micron filter (standard size filter for dissolved metal analyses). Filter approximately 10 milliliters of 10% nitric acid through the filtration system and discard. Next filter approximately 10 milliliters of sample water through the system and discard. This procedure should be done three times in order to assure no residues remain on the filter. A full aliquot of sample water may now be placed in the filter funnel and filtered for placement in sample bottles.

If sample aren't real turbulent (ie dirty)

The above procedure must be performed between each sample collection.

2.7 Sample Containers and Preservation

Ground-water samples must be transferred in the field from the sampling equipment to a container specifically prepared for the given analytical parameter. The appropriate bottles and preservatives will be obtained from the contracted analytical laboratory.

Sample containers shall be labeled in indelible ink with the following information: date and time (military) of sample collection, sample location, required analysis, sampler's initials, preservative, and project identification. Water levels should be marked on sample

How about a seal/tap over cap?
VOCs are 0 hdsp.

bottles which are only partially filled to assure the lab that no leakage or tampering has occurred.

Preservatives required for specific parameters should be supplied by the contracted laboratory in individual, color-coded containers for ease of identification. Preservatives should be added to the sample following collection, and indicated on the sample container.

2.8 Measurement of Field Parameters

Specific conductance, temperature, dissolved oxygen, and pH should be measured at the time of sample collection. Meters should be calibrated, using standard solutions, at the beginning of each sampling day prior to well evacuation and sample collection.

Calibration of the pH meter should be consistent with the instruction manual provided. A minimum of two pH standards within the expected range of field readings must be used for calibration. Sample readings shall be recorded to the nearest tenth in standard units (s.u.).

A minimum of two calibration standards within the expected range of field readings should be used to calibrate the specific conductance meter used. The specific conductance meter should be checked both in the morning and at the end of the day to ensure consistency in measurement. Specific conductance readings shall be recorded with no more than three significant figures in umhos/cm.

@ minimum

The temperature of the ground water shall be taken in degrees Celsius using a thermometer covering a range of temperatures reasonable for ground water. Field measurements shall be recorded to a half of a degree in Celsius.

Note meter, etc equipmt name, manufacture model # + ID # if available

Field parameters should be recorded in a waterproof field notebook. Probes should be thoroughly rinsed with distilled water between each measurement.

2.9 Quality Assurance and Quality Control

Per EPA guidelines, a Quality Assurance/Quality Control (QA/QC) program must be implemented for collection of field data. QA/QC samples include:

> Duplicate - A second sample collected from a well or borehole with no decontamination performed between collections. One duplicate sample should be collected for every ten samples or one per day, whichever is greater.
>
> Equipment blank - Distilled water that is transported to the site, opened in the field, and poured over or through the sample collection device, collected in a sample container, and returned to the laboratory. This serves as a check on

sampling device cleanliness. One equipment blank should be analyzed with each analytical batch or every 20 samples, whichever is greater.

Field blank - Distilled water that is transferred from one vessel to another at the sampling site and preserved with the appropriate reagents. This serves as a check on reagent and environmental contamination. One field blank should be analyzed with each analytical batch or every 20 samples, whichever is greater.

Trip blank - Distilled water that is transported to the sampling site and returned to the laboratory without being opened. This serves as a check on sample contamination originating from sample transport, shipping, and from site conditions. One trip blank should be analyzed with each analytical batch or every 20 samples, whichever is less. This QA/QC sample is only applicable when volatile and semi-volatile sampling will be performed.

QA/QC samples shall be prepared in a similar manner to natural samples, including preservation, filtering, and labeling. Laboratory analysis will include the same parameters as natural samples. All QA/QC samples shall be entered into the sample bank as blind samples with appropriate sample identification designed to prevent laboratory bias.

2.10 Chain-of-Custody and Shipping

Chain-of-custody procedures are used for documenting possession and handling of samples from time of collection through laboratory analysis and final disposition. The chain-of-custody used by GeoResearch contains all necessary information to trace the sample from the point of location to it's ultimate disposition.

Chain-of-Custody sheets are shipped with the samples to the laboratory and signed whenever the samples are relinquished. If the form is unsigned by the sampler, the samples may be rejected.

A sample packing sheet identifying each bottle and the requested analysis should be included in each shipment container. Samples should be appropriately packaged to prevent breakage, packed on ice when necessary, and shipped for delivery to the laboratory within 24 hours of sampling.

3.0 FIELD PROTOCOL SUMMARY

Field data collected during ground-water sampling events shall be recorded in a waterproof project notebook. All site specific information should be recorded to aid in analysis of the data.

Wells shall be locked to prevent unauthorized access or vandalism.

Proper protective clothing should be worn during ground-water sampling for health and safety reasons and to prevent possible contamination of the sample and sampling equipment. Disposable gloves shall be worn during sample collection and handling and replaced between each sample collection.

Field personnel shall be attentive to exhaust emissions from generators or vehicles during sample collection. Volatile organic samples are easily contaminated with fumes or airborne constituents.

GEO
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